

Land Data Toolkit

LDT 7.1 Users' Guide

November 7, 2016

Revision 1.3

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National Aeronautics and Space Administration
Goddard Space Flight Center
Greenbelt, Maryland 20771

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1 Introduction

This is the User's Guide for the Land surface Data Toolkit (LDT). This document describes how to download and install the LDT software and instructions on building an executable.

This document consists of several sections, described as follows:

- 1 Introduction:** the section you are currently reading
- 2 Background:** general information about the LDT
- 3 Preliminary Information:** general information, steps, instructions, and definitions used throughout the rest of this document
- 4 Obtaining the Source Code:** the steps needed to download the source code
- 5 Building the Executable:** the steps needed to build the LDT executable

1.1 What's New

1.1.1 Version 7.1

1. Includes MetTimeDScale runmode
2. Includes Metforcproc runmode
3. Supports crop parameters
4. Supports CLM2 parameters
5. Supports Flake parameters
6. Supports Mosaic parameters
7. Supports Noah parameters
8. Supports SiB2 parameters
9. Supports VIC parameters
10. Supports TRMM 3B42 V7 real time precipitation
11. Supports Aquarius L2 soil moisture observations
12. Supports GCOMW AMSR2 L3 soil moisture observations
13. Supports SMOS L2 soil moisture observations
14. Supports simulated GRACE products

1.1.2 Version 7.0

1. This is the initial version developed for processing data inputs to LIS version 7.0 or higher.

2 Background

A key step in preparing for land surface model (LSM) and hydrologic model simulations is ensuring that all parameters and data inputs belong to the same grid, projection, units, etc. The Land surface Data Toolkit (LDT) is an integrated framework designed specifically for processing data inputs for such land surface and hydrological models. The system not only acts as a pre-processor to the NASA Land Information System (LIS), which is an integrated framework designed for multi-model LSM simulations and data assimilation (DA) integrations, but as a land surface-based observation and DA input processor. LDT is also capable of deriving restart inputs and ensuring data quality control for inputs to LSMs and DA routines.

2.1 LDT

LDT provides an environment for processing LSM data and parameters, restart files and data assimilation based inputs (e.g., for bias correction methods). LDT offers and will offer a variety of user options and inputs to processing datasets for use within LIS and even stand-alone models. LDT is being designed with not only LIS in mind but for other independent models and data processing systems as well. This intended design is facilitated by the use of common data formats, like NetCDF, which provide detailed data header information.

LDT shares similar object oriented framework designs as LIS, with a number of points of flexibility known as “plugins”. Specific implementations are added to the framework through the plugin-interfaces. LDT uses the plugin-based architecture to support the processing of different types of observational data sets, ranging from in-situ, satellite and remotely sensed and reanalysis products.

2.2 Summary of key features

The key capabilities of LDT can be summarized as follows:

- Processing and grouping parameters needed for different LSMs and hydrologic models
- Producing observation-based data assimilation inputs (e.g., CDF matching)
- Generate custom-made restart files for LSMs
- Read in a variety of model inputs, for example:

- Land cover maps — UMD AVHRR, MODIS-IGBP, USGS, etc.
- Soil parameters — soil fractions, texture, color, etc.
- Topographic — elevation, slope, aspect, etc.
- Dynamic parameters — greenness fraction, LAI/SAI, albedo, etc.
- Expanding LSM parameter tiling options to include topographic, soils, and other parameter information, beyond just land cover type tiling
- Options for reading in or deriving a land/water mask during processing

3 Preliminary Information

This section provides some preliminary information to make reading this guide easier.

Commands are written with a fixed-width font. E.g.:

```
% cd /path/to/LDT  
% ls  
“... compiler flags, then run gmake.”
```

File names are written in italics. E.g.:

/path/to/LDT/src

4 Obtaining the Source Code

This section describes how to obtain the source code needed to build the LDT executable.

Due to the history of LDT's development, the source code may not be freely distributed. The source code is available only to U.S. government agencies or entities with a U.S. government grant/contract. LDT's web-site explains how qualified persons may request a copy of the source code.

4.1 Public Release Source Code Tar File

After the proper paperwork and Software Usage Agreement have been completed, the qualified person will be given an official LDT revision 7.1 tar-file containing the source code.

1. Create a directory to unpack the tar-file into. Let's call it *TOPLEVELDIR*.
2. Place the tar-file in this directory.
`% mv LDT_public_release_7.1rp3.tar.gz TOPLEVELDIR`
3. Go into this directory.
`% cd TOPLEVELDIR`
4. Run `gzip -dc LDT_public_release_7.1rp3.tar.gz | tar xf -`
This command will unzip and untar the tar-file.

Note that the directory containing the LDT source code will be referred to as *\$WORKING* throughout the rest of this document.

4.2 Checking Out the Source Code

The source code is maintained in a Subversion repository. Only developers may have access to the repository. Developers must use the Subversion client (**svn**) to obtain the LDT source code. If you need any help regarding Subversion, please go to <http://subversion.apache.org/>.

Developers must first obtain access to the LDT source code repository. To obtain access you must contact the LDT team. Once you have access to the repository, you will be given the correct Subversion command to run to checkout the source code.

1. Create a directory to checkout the code into. Let's call it *TOPLEVELDIR*.

2. Go into this directory.

```
% cd TOPLEVELDIR
```

3. Check out the source code into a directory called *src*.

For the public version, run the following command:

```
% svn checkout https://progress.nccs.nasa.gov/svn/lis/tools/ldt/7/public7.1  
src
```

Note that the directory containing the LDT source code will be referred to as *\$WORKING* throughout the rest of this document.

Source code documentation may be found on LDT's web-site. Follow the "Documentation" link.

5 Building the Executable

This section describes how to build the source code and create LDT's executable — named LDT.

5.1 Development Tools

This code has been compiled and run on Linux PC (Intel/AMD based) systems, IBM AIX systems, and SGI Altix systems. These instructions expect that you are using such a system. In particular you need:

- Linux
 - Compilers
 - * either Intel Fortran Compiler version 13 (13.1.3.192 or higher)
or version 14, both with corresponding Intel C Compiler
 - * or GNU's Compiler Collection 4.9.2, both gfortran and gcc
 - GNU's make, gmake, version 3.77
- IBM
 - XL Fortran version 10.1.0.6
 - GNU's make, gmake, version 3.77
- SGI Altix
 - Intel Fortran Compiler version 12
 - GNU's make, gmake, version 3.77

5.2 Required Software Libraries

In order to build the LDT executable, the following libraries must be installed on your system:

- Earth System Modeling Framework (ESMF) version 5.2.0rp3 (or higher). (<http://www.earthsystemmodeling.org/download/releases.shtml>)
Note that starting with ESMF version 5, the ESMF development team is trying to maintain backwards compatibility with its subsequent releases. The LDT development team, however, has neither compiled nor tested against versions of ESMF newer than 5.2.0rp3.

- JasPer version 1.900.1.
(<http://www.ece.uvic.ca/~frodo/jasper/>).
Note that when running the `configure` command you must include the `--enable-shared` option.
 - GRIB-API version 1.12.3 (or higher).
(<https://software.ecmwf.int/wiki/display/GRIB/Home>)
 - NetCDF either version 3.6.3 or version 4.3.0 (or higher).
(<http://www.unidata.ucar.edu/software/netcdf/>)
Please read the on-line documentation for details on installing NetCDF.
Addtional notes for NetCDF 4:
 - You must also choose whether to compile with compression enabled. Compiling with compression enabled requires HDF 5 and zlib libraries. To enable compression, add `--enable-netcdf-4` to the `configure` options. To disable compression, add `--disable-netcdf-4` to the `configure` options.
- An example of installing NetCDF 4 without compression:
- ```
% ./configure --prefix=$HOME/local/netcdf-4.3.0 --disable-netcdf-4
% gmake
% gmake install
```
- An example of installing NetCDF 4 with compression:
- ```
% CPPFLAGS=-I$HOME/local/hdf5/1.8.11/include \
> LDFLAGS=-L$HOME/local/hdf5/1.8.11/lib \
> ./configure --prefix=$HOME/local/netcdf/4.3.0 --enable-netcdf-4
% gmake
% gmake install
```
- You must also download the *netcdf-fortran-4.2.tar.gz* file. First install the NetCDF C library, then install the NetCDF Fortran library. Again, please read the on-line documentation for more details.
- An example of installing the NetCDF 4 Fortran library:
- ```
% LD_LIBRARY_PATH=$HOME/local/netcdf/4.3.0/lib:$LD_LIBRARY_PATH \
> CPPFLAGS=-I$HOME/local/netcdf/4.3.0/include \
> LDFLAGS=-L$HOME/local/netcdf/4.3.0/lib \
> ./configure --prefix=$HOME/local/netcdf/4.3.0
% gmake
% gmake install
```

## 5.3 Optional Software Libraries

The following libraries are not required to compile LDT. They are used to extend the functionality of LDT.

- HDF

You may choose either HDF version 4, HDF version 5, or both.

HDF is used to support a number of remote sensing datasets.

If you wish to use MODIS snow cover area observations or NASA AMSR-E soil moisture observations, then you need HDF 4 support.

If you wish to use ANSA snow cover fraction observations, then you need HDF 5 support.

If you wish to use PMW snow observations, then you need both HDF 4 and HDF 5 support.

- HDF 4

If you choose to have HDF version 4 support, please download the HDF source for version 4.2r4 (or later) from (<http://www.hdfgroup.org/products/hdf4>) and compile the source to generate the HDF library. Make sure that you configure the build process to include the Fortran interfaces by adding the `--enable-fortran` option to the `configure` command.

Note that HDF4 contains its own embedded version of NetCDF. You must disable this support by adding the `--disable-netcdf` option to the `configure` command.

Note that when compiling LDT with HDF 4 support, you must also download and compile HDF-EOS2 (<http://hdfeos.org/>).

- HDF 5

If you choose to have HDF version 5 support, please download the HDF source for version 1.8.11 (or later) from (<http://www.hdfgroup.org/HDF5/>) and compile the source to generate the HDF library. Make sure that you configure the build process to include the Fortran interfaces by adding the `--enable-fortran` option to the `configure` command.

To install these libraries, follow the instructions provided at the various URL listed above. These optional libraries have their own dependencies, which should be documented in their respective documentation.

Note that due to the mix of programming languages (Fortran and C) used by LDT, you may run into linking errors when building the LDT executable. This is often due to (1) the Fortran compiler and the C compiler using different cases (upper case vs. lower case) for external names, and (2) the Fortran compiler and C compiler using a different number of underscores for external names.

When compiling code using Absoft's Pro Fortran SDK, set the following compiler options:

```
-YEXT_NAMES=LCS -s -YEXT_SFX=_ -YCFRL=1
```

These must be set for each of the above libraries.

## 5.4 Build Instructions

1. Perform the steps described in Section 4 to obtain the source code.
2. Goto the `$WORKING` directory. This directory contains two scripts for building the LDT executable: `configure` and `compile`.
3. Set the `LDT_ARCH` environment variable based on the system you are using. The following commands are written using Bash shell syntax.
  - For an AIX system  
`% export LDT_ARCH=AIX`
  - For a Linux system with the Intel Fortran compiler  
`% export LDT_ARCH=linux_ifc`
  - For a Linux system with the Absoft Fortran compiler  
`% export LDT_ARCH=linux_absoft`
  - For a Linux system with the Lahey Fortran compiler  
`% export LDT_ARCH=linux_lf95`

It is suggested that you place this command in your `.profile` (or equivalent) startup file.

4. Run the `configure` script first by typing:

```
% ./configure
```

This script will prompt the user with a series of questions regarding support to compile into LDT, requiring the user to specify the locations of the required and optional libraries via several LDT specific environment variables. The following environment variables are used by LDT.

| Variable    | Description                | Usage    |
|-------------|----------------------------|----------|
| LDT_FC      | Fortran 90 compiler        | required |
| LDT_CC      | C compiler                 | required |
| LDT_MODESMF | path to ESMF module files  | required |
| LDT_LIBESMF | path to ESMF library files | required |
| LDT_JASPER  | path to JasPer library     | required |
| LDT_GRIBAPI | path to GRIB-API library   | required |
| LDT_NETCDF  | path to NetCDF library     | required |
| LDT_HDF4    | path to HDF4 library       | optional |
| LDT_HDF5    | path to HDF5 library       | optional |
| LDT_HDFEOS  | path to HDFEOS library     | optional |

Note that the CC variable must be set to a C compiler, not a C++ compiler. A C++ compiler may mangle internal names in a manner that is not consistent with the Fortran compiler. This will cause errors during linking. It is suggested that you add these definitions to your *.profile* (or equivalent) startup file.

You may encounter errors either when trying to compile LDT or when trying to run LDT because the compiler or operating system cannot find these libraries. To fix this, you must add these libraries to your \$LD\_LIBRARY\_PATH environment variable. For example, say that you are using ESMF, GRIB-API, NetCDF, and HDF5. Then you must execute the following command (written using Bash shell syntax):

```
% export LD_LIBRARY_PATH=$LDT_HDF5/lib:$LDT_LIBESMF:$LDT_NETCDF/lib:$LDT_GRIBAPI/lib:$LD_LIBRARY_PATH
```

It is also suggested that you add this command to your *.profile* (or equivalent) startup file.

- An example execution of the configure script is shown below:

```
% ./configure

Setting up configuration for LDT version 1.0...
Optimization level (-2=strict checks, -1=debug, 0,1,2,3, default=2):
Assume little/big_endian data format (1-little, 2-big, default=2):
Use openMP parallelism (1=yes, 0-no, default=0):
NETCDF version (3 or 4, default=4)?:
NETCDF use shuffle filter? (1=yes, 0-no, default = 1):
NETCDF use deflate filter? (1=yes, 0-no, default = 1):
NETCDF use deflate level? (1 to 9=yes, 0-no, default = 9):
Use HDF4? (1=yes, 0-no, default=1):
Use HDF5? (1=yes, 0-no, default=1):
Use HDFEOS? (1=yes, 0-no, default=1):
Include date/time stamp history? (1=yes, 0-no, default=1):

configure.ldt file generated successfully
```

```

Settings are written to configure.ldt in the make directory
If you wish to change settings, please edit that file.
To compile, run the compile script.

```

At each prompt, select the desired value. If you desire the default value, then you may simply press the Enter key.

Most of the configure options are be self-explanatory. Here are a few specific notes:

- for `Use openMP parallelism (1=yes, 0=no, default=0):`, select the default value of 0. OpenMP support is experimental. **Please do not use.**
- for `Assume little/big_endian data format (1-little, 2-big, default=2):`, select the default value of 2. By default, LDT reads and writes binary data in the big endian format. Only select the value of 1, if you have reformatted all required binary data into the little endian format.
- for `Use GRIBAPI? (1=yes, 0=no, default=1):`, select the default value of 1. Technically, GRIB support is not required by LDT; however, the most of the commonly used met forcing data are in GRIB, making GRIB support a practical requirement.

Note that due to an issue involving multiple definitions within the NetCDF 3 and HDF 4 libraries, you cannot compile LDT with support for both NetCDF 3 and HDF 4 together.

Note that if you compiled NetCDF 4 without compression, then when specifying `NETCDF version (3 or 4, default=4):`, select 3. Then you must manually append `-lncdff` to the `LDFLAGS` variable in the *make/configure.ldt* file.

6. Compile the LDT source code by running the *compile* script.

```
% ./compile
```

This script will compile the libraries provided with LDT, the dependency generator and then the LDT source code. The executable *LDT* will be placed in the `$WORKING` directory upon successful completion of the *compile* script.

7. Finally, copy the *LDT* executable into your running directory, `$RUNNING`.

## 5.5 Generating documentation

LDT code uses the ProTex (<http://gmao.gsfc.nasa.gov/software/protex/>) documenting system [1]. The documentation in L<sup>A</sup>T<sub>E</sub>X format can be produced by using the `doc.csh` in the `$WORKING/utils` directory. This command produces documentation, generating a number of L<sup>A</sup>T<sub>E</sub>X files. These files can be easily converted to pdf using utilites such as `pdflatex`.

## 6 Running the Executable

This section describes how to run the LDT executable.

First you should create a directory to run LDT in. It is suggested that you run LDT in a directory that is separate from your source code. This running directory shall be referred to as *\$RUNNING*. Next, copy the LDT executable into your running directory.

```
% cp $WORKING/LDT $RUNNING
```

The single-process version of LDT is executed by the following command issued in the *\$RUNNING* directory.

```
% ./LDT
```

Note that when using the Lahey Fortran compiler, you must issue this command to run the single-process version of LDT:

```
% ./LDT -Wl,T
```

Some systems require that you submit your job into a batch queue. Please consult with your system administrator for instructions on how to do this.

Note that before running LDT, you must set your environment to have an unlimited stack size. For the Bash shell, run

```
% ulimit -s unlimited
```

To customize your run, you must modify the *ldt.config* configuration file. See Section 7 for more information.

## 7 LDT Config File

This section describes the options in the *ldt.config* file.

Not all options described here are available in the public version of LDT.

### 7.1 Overall driver options

**LDT running mode:** specifies the running mode used in LDT. Acceptable values are:

| Value                           | Description                                               |
|---------------------------------|-----------------------------------------------------------|
| “LSM parameter processing”      | LSM Parameter Processing Option                           |
| “DA preprocessing”              | Data Assimilation Preprocessing Option                    |
| “Ensemble restart processing”   | Deriving an ensemble restart file Option                  |
| “Restart preprocessing”         | LSM Restart File Preprocessing Option                     |
| “Metforce processing”           | Meteorological forcing processing Option (similar to LIS) |
| “Metforce temporal downscaling” | Meteorological forcing temporal downscaling               |

|                          |                            |
|--------------------------|----------------------------|
| <b>LDT running mode:</b> | "LSM parameter processing" |
|--------------------------|----------------------------|

**Processed LSM parameter filename:** specifies the output filename (with netcdf extension) of the LSM parameters processed in LDT to go into LIS. See a sample *lis\_input.d01.nc* (Appendix A) file for a complete specification description.

|                                          |                    |
|------------------------------------------|--------------------|
| <b>Processed LSM parameter filename:</b> | ./lis_input.d01.nc |
|------------------------------------------|--------------------|

**LIS number of nests:** specifies the number of nests used for the run. Values 1 or higher are acceptable. The maximum number of nests is limited by the amount of available memory on the system. The specifications for different nests are done using white spaces as the delimiter. Please see below for further explanations. Note that all nested domains should run on the same projection and same land surface model.

|                             |   |
|-----------------------------|---|
| <b>LIS number of nests:</b> | 1 |
|-----------------------------|---|

**Number of surface model types:** specifies the number of surface model types selected for the LIS simulation. Acceptable values are 1 or higher.

|                                  |
|----------------------------------|
| Number of surface model types: 1 |
|----------------------------------|

**Surface model types:** specifies the names of the surface model types. Options include (but to be expanded later):

| Value     | Description             |
|-----------|-------------------------|
| LSM       | Land surface model type |
| Openwater | Openwater surface type  |

|                            |
|----------------------------|
| Surface model types: "LSM" |
|----------------------------|

**Land surface model:** specifies the land surface model to be run. Need to select the model you want to run in LIS-7, so the appropriate model parameters are included in the output netcdf file for LIS. Acceptable values are:

| Value       | Description            |
|-------------|------------------------|
| none        | Template LSM           |
| Noah.2.7.1  | Noah 2.7.1             |
| Noah.3.2    | Noah 3.2               |
| Noah.3.3    | Noah 3.3               |
| Noah.3.6    | Noah 3.6               |
| Noah-MP.3.6 | Noah-MP 3.6            |
| CLM.2       | CLM version 2.0        |
| VIC.4.1.1   | VIC 4.1.1              |
| VIC.4.1.2   | VIC 4.1.2              |
| Mosaic      | Mosaic                 |
| HySSIB      | HySSIB                 |
| CLSMF2.5    | Catchment, Fortuna 2.5 |
| SAC.3.5.6   | Sacramento             |
| SNOW17      | Snow17                 |
| RDHM.3.5.6  | Sacramento+snow17      |
| GeoWRSI.2   | GeoWRSI, v2.0          |

|                              |
|------------------------------|
| Land surface model: Noah.3.3 |
|------------------------------|

**Lake model:** specifies the lake model type used in a LIS run. Currently, only the FLake lake model is incorporated in LIS, and both LDT and LIS are set up for additional support of lake model installation and development. For now, the option “none” is recommended.

|             |      |
|-------------|------|
| Lake model: | none |
|-------------|------|

**Routing model:** specifies the river routing model used in a LIS run. Currently, only the HYMAP routing scheme parameters are supported in LDT.

|                |       |
|----------------|-------|
| Routing model: | HYMAP |
|----------------|-------|

**Water fraction cutoff value:** specifies what gridcell fraction is to be represented by water (e.g., 0.6 would be 60% covered by water pixels). This value acts as a threshold in determining which gridcell will be included as a water or land point (used also in deriving the land/water mask).

|                              |     |
|------------------------------|-----|
| Water fraction cutoff value: | 0.5 |
|------------------------------|-----|

**Number of met forcing sources:** specifies the number of met forcing datasets to be used. Acceptable values are 0 or higher.

|                                |   |
|--------------------------------|---|
| Number of met forcing sources: | 1 |
|--------------------------------|---|

**Met forcing sources:** specifies the meteorological forcing data sources used for a LIS run.

For more information about LIS's meteorological forcing data reader options, please see the "Land Information System (LIS) Users' Guide" for more information.

Acceptable values for the sources are:

| Value              | Description                                             |
|--------------------|---------------------------------------------------------|
| “NONE”             | none                                                    |
| “CMAP”             | CMAP precipitation fields                               |
| “CPC CMORPH”       | CMORPH precipitation fields                             |
| “ECMWF”            | ECMWF near-realtime analysis                            |
| “ECMWF reanalysis” | ECMWF reanalysis(II), based on Berg et al.(2003)        |
| “GDAS”             | GDAS near-realtime analysis                             |
| “GEOS”             | NASA-GEOS (v3-5) forcing analysis                       |
| “GEOS5 forecast”   | GEOS v5 forecast fields                                 |
| “GFS”              | NCEP-GFS forecast fields                                |
| “GLDAS”            | Coarse-scale GLDAS-1 forcing                            |
| “GSWP1”            | GSWP1 forcing                                           |
| “GSWP2”            | GSWP2 forcing                                           |
| “MERRALand”        | NASA’s MERRA-Land reanalysis                            |
| “NAM242”           | NCEP-NAM 242 resolution (Alaska)                        |
| “NARR”             | North American Regional Reanalysis                      |
| “NLDAS1”           | NLDAS1 analysis fields                                  |
| “NLDAS2”           | NLDAS2 analysis fields                                  |
| “PRINCETON”        | Global Princeton long-term forcing records              |
| “RFE2(daily)”      | CPC Daily Rainfall estimator fields                     |
| “RFE2(gdas)”       | CPC RFE2 rainfall adjusted with GDAS/CMAP precipitation |
| “CHIRPS2”          | UCSB CHIRPS v2.0 precipitation dataset                  |
| “CPC STAGEII”      | CPC Stage II radar-based rainfall                       |
| “CPC STAGEIV”      | CPC Stage IV radar-based rainfall                       |
| “TRMM 3B42RTV7”    | TRMM-based 3B42 real-time rainfall                      |
| “TRMM 3B42V6”      | TRMM-based 3B42 V6 rainfall                             |
| “TRMM 3B42V7”      | TRMM-based 3B42 V7 rainfall                             |

|                      |          |
|----------------------|----------|
| Met forcing sources: | "NLDAS2" |
|----------------------|----------|

**Blending method for forcings:** specifies the blending method to combine forcings if more than one forcing dataset is used. User-entry activated only when the “Metforce processing” run mode is selected.

Acceptable values are:

| Value    | Description                                                                                       |
|----------|---------------------------------------------------------------------------------------------------|
| overlay  | datasets are overlaid on top of each other in the order they are specified                        |
| ensemble | each forcing dataset is assigned to a separate ensemble member (option not available yet in LDT). |

### **Blending method for forcings: overlay**

**Met spatial transform methods:** specifies the type of spatial transform or interpolation scheme to apply to the forcing dataset(s) selected. Acceptable values are:

| Value             | Description                                                |
|-------------------|------------------------------------------------------------|
| “average”         | Upscale via averaging                                      |
| “neighbor”        | Nearest neighbor scheme                                    |
| “bilinear”        | Bilinear interpolation scheme                              |
| “budget-bilinear” | Conservative interpolation scheme (“conserves” quantities) |

Bilinear interpolation uses 4 neighboring points to compute the interpolation weights. The conservative approach uses 25 neighboring points. This option is designed to conserve water, like for precipitation. Also, nearest neighbor can be used, which may better preserve large pixels (e.g., 1x1 deg), if needed. “Average” can also be selected if upscaling from finer-scale meteorological fields (e.g., going from 4 KM to 0.25 deg).

### **Met spatial transform methods: bilinear**

**Topographic correction method (met forcing):** specifies whether to use elevation correction on select forcing fields. Acceptable values are:

| Value        | Description                                     |
|--------------|-------------------------------------------------|
| “none”       | Do not apply topographic correction for forcing |
| “lapse-rate” | Use lapse rate correction for forcing           |

Current meteorological forcing datasets supported for applying this lapse-rate adjustment to the temperature, humidity, pressure and downward longwave fields, include: NLDAS1, NLDAS2, NAM242, GDAS, PRINCETON, and ECMWF Future forcing dataset options will include: GEOS, GLDAS, GFS, ECMWF\_reanalysis, and possible others.

ECMWF and GDAS forcing types include several terrain height maps and not just one overall, either due to change in versions or gridcell size, respective.

### **Topographic correction method (met forcing): "lapse-rate"**

**Temporal interpolation method (met forcing):** specifies the type of temporal interpolation scheme to apply to the met forcing data. Acceptable values

are:

| Value     | Description      |
|-----------|------------------|
| linear    | linear scheme    |
| trilinear | uber next scheme |

The linear temporal interpolation method computes the temporal weights based on two points. Ubernext computes weights based on three points. Currently the ubernext option is implemented only for the GSWP forcing.

|                                                     |
|-----------------------------------------------------|
| Temporal interpolation method (met forcing): linear |
|-----------------------------------------------------|

**Met forcing chosen ensemble member:** specifies the desired ensemble member from a given forcing data source to be assigned across all LIS ensemble members. This option is enabled only if the met forcing data source contains its own ensembles.

|                                     |
|-------------------------------------|
| Met forcing chosen ensemble member: |
|-------------------------------------|

**Temporal downscaling method:** specifies the temporal downscaling method to disaggregate a coarser forcing dataset into finer timesteps (e.g., go from daily to hourly).

User-entry activated only when the “Metforce temporal downscaling” run mode is selected.

Acceptable values are:

| Value              | Description                                                                                                                                                                        |
|--------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| “Simple weighting” | Use finer timescale forcing dataset to estimate weights and downscale coarser forcing dataset. The finer timescale forcing dataset should be defined first in the ldt.config file. |

|                                                 |
|-------------------------------------------------|
| Temporal downscaling method: "Simple weighting" |
|-------------------------------------------------|

**Processed metforcing output interval:** specifies the output interval for the processed meteorological forcing files. Entries are character-based names, like 6hr or 1da.

```
Processed metforcing output interval: "6hr"
```

**Metforcing processing interval:** specifies the processing temporal interval for which meteorological forcing files are commonly and temporally aggregated (or downscaled) to when temporally downscaling a dataset.

```
Metforcing processing interval: "1da"
```

**Forcing variables list file:** specifies the file containing the list of forcing variables to be used. Please refer to the sample forcing\_variables.txt (Section ??) file for a complete specification description.

```
Forcing variables list file: ./input/forcing_variables.txt
```

**LDT diagnostic file:** specifies the name of run time LDT diagnostic file.

```
LDT diagnostic file: ldtlog
```

**Mask-parameter fill diagnostic file:** specifies the name of the output diagnostic file for wherever mask-parameter points have forced agreement for a given landmask and parameter.

```
Mask-parameter fill diagnostic file: LDTOUTPUT_temp/MPFilltest.log
```

**LDT output directory:** specifies the directory name for outputs from LDT Acceptable values are any 40 character string. The default value is set to OUTPUT.

```
LDT output directory: OUTPUT
```

**Undefined value:** specifies the undefined value. The default is set to -9999.

|                  |         |
|------------------|---------|
| Undefined value: | -9999.0 |
|------------------|---------|

**Number of ensembles per tile:** specifies the number of ensembles of tiles to be used. The value should be greater than or equal to 1.

|                               |   |
|-------------------------------|---|
| Number of ensembles per tile: | 1 |
|-------------------------------|---|

The following options are used for subgrid tiling based on vegetation or other parameter types (e.g., soil type, elevation, etc.), and are required for generating an ensemble restart file or downscaling to a single-member restart file from an ensemble one. See the section on ensemble restart files for more information.

**Maximum number of surface type tiles per grid:** defines the maximum surface type tiles per grid (this can be as many as the total number of vegetation types). Note: Allowable values are greater than or equal to 1. Note that the entry here should exactly match the entry used in the lis.config file.

|                                                  |
|--------------------------------------------------|
| Maximum number of surface type tiles per grid: 1 |
|--------------------------------------------------|

**Minimum cutoff percentage (surface type tiles):** defines the smallest percentage of a cell for which to create a tile. The percentage value is expressed as a fraction. Allowable values are greater than or equal to 0. Note that the entry here should exactly match the entry used in the lis.config file.

|                                                      |
|------------------------------------------------------|
| Minimum cutoff percentage (surface type tiles): 0.05 |
|------------------------------------------------------|

**Maximum number of soil texture tiles per grid:** defines the maximum soil texture tiles per grid (this can be as many as the total number of soil texture types). Allowable values are greater than or equal to 1. Note that the entry here should exactly match the entry used in the lis.config file.

|                                                  |
|--------------------------------------------------|
| Maximum number of soil texture tiles per grid: 1 |
|--------------------------------------------------|

**Minimum cutoff percentage (soil texture tiles):** defines the smallest percentage of a cell for which to create a tile. The percentage value is expressed as a fraction. Allowable values are greater than or equal to 0. Note that the entry here should exactly match the entry used in the lis.config file.

```
Minimum cutoff percentage (soil texture tiles): 0.05
```

**Maximum number of soil fraction tiles per grid:** defines the maximum soil fraction tiles per grid (this can be as many as the total number of soil fraction types). Allowable values are greater than or equal to 1. Note that the entry here should exactly match the entry used in the lis.config file.

```
Maximum number of soil fraction tiles per grid: 1
```

**Minimum cutoff percentage (soil fraction tiles):** defines the smallest percentage of a cell for which to create a tile. The percentage value is expressed as a fraction. Allowable values are greater than or equal to 0. Note that the entry here should exactly match the entry used in the lis.config file.

```
Minimum cutoff percentage (soil fraction tiles): 0.05
```

**Maximum number of elevation bands per grid:** defines the maximum elevation bands per grid (this can be as many as the total number of elevation band types). Allowable values are greater than or equal to 1. Note that the entry here should exactly match the entry used in the lis.config file.

```
Maximum number of elevation bands per grid: 1
```

**Minimum cutoff percentage (elevation bands):** defines the smallest percentage of a cell for which to create a tile. The percentage value is expressed as a fraction. Allowable values are greater than or equal to 0. Note that the entry here should exactly match the entry used in the lis.config file.

```
Minimum cutoff percentage (elevation bands): 0.05
```

**Maximum number of slope bands per grid:** defines the maximum slope bands per grid (this can be as many as the total number of slope band types). Allowable values are greater than or equal to 1. Note that the entry here should exactly match the entry used in the lis.config file.

```
Maximum number of slope bands per grid: 1
```

**Minimum cutoff percentage (slope bands):** defines the smallest percentage of a cell for which to create a tile. The percentage value is expressed as a fraction. Allowable values are greater than or equal to 0. Note that the entry here should exactly match the entry used in the lis.config file.

```
Minimum cutoff percentage (slope bands): 0.05
```

**Maximum number of aspect bands per grid:** defines the maximum aspect bands per grid (this can be as many as the total number of aspect band types). Allowable values are greater than or equal to 1. Note that the entry here should exactly match the entry used in the lis.config file.

```
Maximum number of aspect bands per grid: 1
```

**Minimum cutoff percentage (aspect bands):** defines the smallest percentage of a cell for which to create a tile. The percentage value is expressed as a fraction. Allowable values are greater than or equal to 0. Note that the entry here should exactly match the entry used in the lis.config file.

```
Minimum cutoff percentage (aspect bands): 0.05
```

This section specifies the 2-d layout of the processors in a parallel processing environment.

Currently LDT does not have parallelization capability,  
but there are future plans to incorporate this feature.

These config file entries do not need to be specified at this time.

The user can specify the number of processors along the east-west dimension and north-south dimension using **Number of processors along x:** and **Number of processors along y:**, respectively. Note that the layout of processors should match the total number of processors used. For example, if 8 processors are used, the layout can be specified as 1x8, 2x4, 4x2, or 8x1.

|                               |   |
|-------------------------------|---|
| Number of processors along x: | 2 |
| Number of processors along y: | 2 |

**Output methodology:** specifies whether to write output as a 1-D array containing only land points or as a 2-D array containing both land and water points. 1-d tile space includes the subgrid tiles and ensembles. 1-d grid space includes a vectorized, land-only grid-averaged set of values. Acceptable values are:

| Value          | Description                       |
|----------------|-----------------------------------|
| “none”         | Do not write output               |
| “1d tilespace” | Write output in a 1-D tile domain |
| “2d gridspace” | Write output in a 2-D grid domain |
| “1d gridspace” | Write output in a 1-D grid domain |

The default value is ”2d gridspace”.

|                                    |
|------------------------------------|
| Output methodology: "2d gridspace" |
|------------------------------------|

**Output data format:** specifies the format of the model output data. Acceptable values are:

| Value    | Description                   |
|----------|-------------------------------|
| “binary” | Write output in binary format |
| “grib1”  | Write output in GRIB-1 format |
| “netcdf” | Write output in netCDF format |

The default value is ”netcdf”.

|                            |
|----------------------------|
| Output data format: netcdf |
|----------------------------|

**Output naming style:** specifies the style of the model output names and their organization. Acceptable values are:

| Value               | Description                      |
|---------------------|----------------------------------|
| “2 level hierarchy” | 2 levels of hierarchy            |
| “3 level hierarchy” | 3 levels of hierarchy            |
| “4 level hierarchy” | 4 levels of hierarchy            |
| “WMO convention”    | WMO convention for weather codes |

The default value is ”3 level hierarchy”.

```
Output naming style: "3 level hierarchy"
```

## 7.2 Domain specification

This section of the config file specifies the LIS running domain (domain over which the simulation is carried out). The specification of the LIS Run domain section depends on the type of LIS domain and projection used. Section 7.1 lists the projections that LIS supports.

**Map projection of the LIS domain:** specifies the output LIS domain grid to be used with LIS. Acceptable values are:

| Value    | Description                                                |
|----------|------------------------------------------------------------|
| latlon   | Lat/Lon projection with SW to NE data ordering             |
| lambert  | Lambert conformal projection with SW to NE data ordering   |
| gaussian | Gaussian domain                                            |
| polar    | Polar stereographic projection with SW to NE data ordering |
| hrap     | HRAP domain (based on polar stereographic projection)      |
| mercator | Mercator projection with SW to NE data ordering            |

```
Map projection of the LIS domain: latlon
```

### 7.2.1 Cylindrical lat/lon

This section describes how to specify a cylindrical latitude/longitude projection. See Appendix B for more details about setting these values.

```
Run domain lower left lat: 25.625
Run domain lower left lon: -124.125
Run domain upper right lat: 52.875
Run domain upper right lon: -67.875
Run domain resolution (dx): 0.25
Run domain resolution (dy): 0.25
```

### 7.2.2 Lambert conformal

This section describes how to specify a Lambert conformal projection. See Appendix C for more details about setting these values.

|                              |          |
|------------------------------|----------|
| Run domain lower left lat:   | 32.875   |
| Run domain lower left lon:   | -104.875 |
| Run domain true lat1:        | 36.875   |
| Run domain true lat2:        | 36.875   |
| Run domain standard lon:     | -98.875  |
| Run domain resolution:       | 25.0     |
| Run domain x-dimension size: | 40       |
| Run domain y-dimension size: | 30       |

### 7.2.3 Gaussian

This section describes how to specify a Gaussian projection. See Appendix D for more details about setting these values.

|                                   |           |
|-----------------------------------|-----------|
| Run domain first grid point lat:  | -89.27665 |
| Run domain first grid point lon:  | 0.0       |
| Run domain last grid point lat:   | 89.27665  |
| Run domain last grid point lon:   | -0.9375   |
| Run domain resolution dlon:       | 0.9375    |
| Run domain number of lat circles: | 95        |

### 7.2.4 Polar stereographic

This section describes how to specify a polar stereographic projection. See Appendix E for more details about setting these values.

|                            |          |
|----------------------------|----------|
| Run domain lower left lat: | 32.875   |
| Run domain lower left lon: | -104.875 |
| Run domain true lat:       | 36.875   |
| Run domain standard lon:   | -98.875  |
| Run domain orientation:    | 0.0      |
| Run domain resolution:     | 25.0     |

|                              |    |
|------------------------------|----|
| Run domain x-dimension size: | 40 |
| Run domain y-dimension size: | 30 |

### 7.2.5 HRAP

This section describes how to specify a HRAP projection. See Appendix F for more details about setting these values.

|                               |      |
|-------------------------------|------|
| Run domain lower left hrap y: | 48   |
| Run domain lower left hrap x: | 17   |
| Run domain hrap resolution:   | 1    |
| Run domain x-dimension size:  | 1043 |
| Run domain y-dimension size:  | 774  |

### 7.2.6 Mercator

This section describes how to specify a Mercator projection. See Appendix G for more details about setting these values.

|                              |          |
|------------------------------|----------|
| Run domain lower left lat:   | 32.875   |
| Run domain lower left lon:   | -104.875 |
| Run domain true lat1:        | 36.875   |
| Run domain standard lon:     | -98.875  |
| Run domain resolution:       | 25.0     |
| Run domain x-dimension size: | 40       |
| Run domain y-dimension size: | 30       |

## 7.3 Parameters

**Landcover data source:** specifies the land cover dataset source to be read in. Current landcover source options include:

| Value        | Description                                                                                                                                                                                                                                          |
|--------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| AVHRR        | Univ. of Maryland 1992-93 AVHRR landcover map.<br>Please see: <a href="http://glcf.umd.edu/data/landcover/">http://glcf.umd.edu/data/landcover/</a>                                                                                                  |
| AVHRR_GFS    | Similar to "AVHRR" option above but on a GFS grid.                                                                                                                                                                                                   |
| MODIS_Native | Terra-MODIS sensor-based IGBP land classification map, modified by NCEP. For more info, please see:<br><a href="http://www.ral.ucar.edu/research/land/technology/noahmp_lsm.php">http://www.ral.ucar.edu/research/land/technology/noahmp_lsm.php</a> |
| MODIS_LIS    | Similar dataset as "MODIS_Native" above but processed by LIS-team.                                                                                                                                                                                   |
| USGS_Native  | The 24-category USGS native landcover map. See:<br><a href="http://www.ral.ucar.edu/research/land/technology/noahmp_lsm.php">http://www.ral.ucar.edu/research/land/technology/noahmp_lsm.php</a>                                                     |
| USGS_LIS     | Similar dataset as "USGS_Native" but processed by LIS-team.                                                                                                                                                                                          |
| ALMIPII      | AMMA/ALMIP Phase-2 landcover input option. For more info:<br><a href="http://www.cnrm.meteo.fr/amma-moana/amma_surf/almip2/input.html">http://www.cnrm.meteo.fr/amma-moana/amma_surf/almip2/input.html</a>                                           |
| CLSMF2.5     | CLSM Fortuna 2.5 landcover dataset.                                                                                                                                                                                                                  |
| ISA          | Impervious Surface Area (ISA) landcover dataset.                                                                                                                                                                                                     |
| CONSTANT     | Ability to set a constant landcover type for a set classification.                                                                                                                                                                                   |

|                        |                |
|------------------------|----------------|
| Landcover data source: | "MODIS_Native" |
|------------------------|----------------|

**Landcover classification:** specifies the land cover classification type. Land cover or use classification types have been developed over the years by various organizations (e.g., USGS, IGBP) and research groups (e.g., satellite missions associated with groups, like UMD, BU, etc.). For more information on some of these different land classifications and their characteristics, please refer to: <http://edc2.usgs.gov/glcc/globdoc2.0.php>

Acceptable values are:

| Value     | Description        |
|-----------|--------------------|
| UMD       | 14 Landcover types |
| IGBP      | 16 Landcover types |
| USGS      | 24 Landcover types |
| IGBPNCPEP | 20 Landcover types |
| MOSAIC    | 7 Landcover types  |
| ISA       | 13 Landcover types |
| CONSTANT  | 2 Landcover types  |

|                           |       |
|---------------------------|-------|
| Landcover classification: | "UMD" |
|---------------------------|-------|

**Landcover file:** specifies the location of the vegetation classification file.

**Landcover spatial transform:** indicates which spatial transform (i.e., upscale or downscale) type is to be applied to the landcover map. Options include:

| Value    | Description                                                                                                                                                                                                                         | Note: |
|----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|
| none     | Data is on same grid as LIS output domain                                                                                                                                                                                           |       |
| mode     | Upscale by selecting dominant type for each gridcell                                                                                                                                                                                |       |
| neighbor | Use nearest neighbor to select closest value                                                                                                                                                                                        |       |
| tile     | Read in tiled data or upscale by estimating gridcell fractions<br>“tile” is a special case for landcover, which allows for reading in landcover data already in tiled form, or creating tiles from finer resolution landcover data. |       |

```
Landcover file: ./input/1KM/landcover_UMD.1gd4r
Landcover spatial transform: tile
```

**Landcover fill option:** specifies the landcover classification data fill option. Options include:

| Value    | Description                                |
|----------|--------------------------------------------|
| none     | Do not apply missing value fill routines   |
| neighbor | Use nearest neighbor to fill missing value |

**Landcover fill value:** indicates which landcover value to be used if an arbitrary value fill is needed. (For example, when the landmask indicates a land point but no existing landcover point, a value of 5 could be assigned if no nearest neighbor values exists to fill).

**Landcover fill radius:** specifies the radius with which to search for nearby value(s) to help fill the missing value.

```
Landcover fill option: neighbor # none, neighbor
Landcover fill radius: 3. # Number of pixels to search for neighbor
Landcover fill value: 5. # Static value to fill where missing
```

This section also outlines the domain specifications of the landcover (and for now landmask) data. If the map projection of parameter data is specified to be lat/lon, the following configuration should be used for specifying landcover data. Note: The Landcover grid domain inputs below are really only required for the “\_LIS” data source options and that do not include “\_Native” in the data source entries. All native parameters do not require the below inputs for LDT. See Appendix B for more details about setting these values.

|                                   |          |
|-----------------------------------|----------|
| <b>Landcover map projection:</b>  | latlon   |
| <b>Landcover lower left lat:</b>  | -59.995  |
| <b>Landcover lower left lon:</b>  | -179.995 |
| <b>Landcover upper right lat:</b> | 89.995   |
| <b>Landcover upper right lon:</b> | 179.995  |
| <b>Landcover resolution (dx):</b> | 0.01     |
| <b>Landcover resolution (dy):</b> | 0.01     |

**Create or readin landmask:** offers the user the option to create or read in land/water mask file information. Options include the ability to impose the mask on landcover and also the other parameter fields.

|                                   |          |
|-----------------------------------|----------|
| <b>Create or readin landmask:</b> | "readin" |
|-----------------------------------|----------|

**Landmask data source:** specifies the land mask dataset source to be read in. If the user is interested in only using the selected landcover data source, then the user can select the same option for the landmask data source.

Other current landmask source options include:

|              |                                                                                                                                                       |
|--------------|-------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Value</b> | <b>Description</b>                                                                                                                                    |
| MOD44W       | The MODIS 44W land-water mask was developed and provided by:<br><a href="http://glcf.umd.edu/data/watermask/">http://glcf.umd.edu/data/watermask/</a> |

|                              |                |
|------------------------------|----------------|
| <b>Landmask data source:</b> | "MODIS_Native" |
|------------------------------|----------------|

**Landmask file:** specifies the location of land/water mask file.

Note: If reading in the MOD44W land-water mask, make sure to enter 'MOD44W' Landmask data source entry.

|                       |                                |
|-----------------------|--------------------------------|
| <b>Landmask file:</b> | ./input/1KM/landmask_UMD.1gd4r |
|-----------------------|--------------------------------|

**Landmask spatial transform:** indicates which spatial transform (i.e., upscale or downscale) type is to be applied to the landmask map. Options include:

|              |                                                                 |
|--------------|-----------------------------------------------------------------|
| <b>Value</b> | <b>Description</b>                                              |
| none         | Data is on same grid as LIS output domain                       |
| mode         | Upscale by selecting dominant type for each gridcell            |
| neighbor     | Use nearest neighbor when downscaling (or upscaling, if needed) |

```
Landmask spatial transform: none
```

This section also outlines the domain specifications of the land/water mask data. The landmask map projection and extents are only needed if you specify “readin” for mask type and if the landmask data source is “MOD44W” or “\_LIS”.

If the map projection of parameter data is specified to be “latlon”, the following extents and resolution configuration should be used for specifying landmask data. See Appendix B for more details about setting these values.

Future landmask data sets will have the projection, grid extents and resolution on the data reader side and not needed to be specified in the ldt config file, depending on the data source.

```
Landmask map projection: latlon
Landmask lower left lat: -59.995
Landmask lower left lon: -179.995
Landmask upper right lat: 89.995
Landmask upper right lon: 179.995
Landmask resolution (dx): 0.01
Landmask resolution (dy): 0.01
```

**Regional mask data source:** specifies a regional land mask dataset source to be read in. Should either match grid domain or be smaller to the LIS run domain.

| Value | Description                                                 |
|-------|-------------------------------------------------------------|
| ESRI  | Binary file type mask produced in ESRI-GIS software.        |
| WRSI  | A BIL-format (binary) mask file associated with WRSI model. |

```
Regional mask data source: "none"
```

**Regional mask file:** specifies the location of a regional mask file. This file can be either an index-based state, country, basin, catchment, etc. map used to mask further beyond the main water/land mask.

```
Regional mask file: ../../input/1KM/regional_statemask.1gd4r
```

**Clip landmask with regional mask:** A logical-based option that uses the regional mask to ‘clip’ the original landmask that is read-in or created. `.true.` turns on the ”clipping” option.

|                                                       |
|-------------------------------------------------------|
| <code>Clip landmask with regional mask: .true.</code> |
|-------------------------------------------------------|

**Regional mask spatial transform:** indicates which spatial transform (i.e., upscale or downscale) type is to be applied to a regional mask map. Options include:

| Value    | Description                                          |
|----------|------------------------------------------------------|
| none     | Data is on same grid as LIS output domain            |
| neighbor | Use nearest neighbor to select closest value         |
| mode     | Upscale by selecting dominant type for each gridcell |

|                                                    |
|----------------------------------------------------|
| <code>Regional mask spatial transform: mode</code> |
|----------------------------------------------------|

This section also outlines the domain specifications of the regional-based land mask data. If the map projection of parameter data is specified to be lat/lon, the following configuration should be used for specifying regional mask data.

See Appendix B for more details about setting these values.

|                                                     |
|-----------------------------------------------------|
| <code>Regional mask map projection: latlon</code>   |
| <code>Regional mask lower left lat: -59.995</code>  |
| <code>Regional mask lower left lon: -179.995</code> |
| <code>Regional mask upper right lat: 89.995</code>  |
| <code>Regional mask upper right lon: 179.995</code> |
| <code>Regional mask resolution (dx): 0.01</code>    |
| <code>Regional mask resolution (dy): 0.01</code>    |

**Rootdepth data source:** specifies the source of the vegetation root depth dataset. Options include:

| Value   | Description               |
|---------|---------------------------|
| none    | No data                   |
| ALMIPII | ALMIP II root depth field |

|                                          |
|------------------------------------------|
| <code>Rootdepth data source: none</code> |
|------------------------------------------|

**Root depth file:** specifies the path and name of the root depth file. Options include:

| Value   | Description               |
|---------|---------------------------|
| none    | No data                   |
| ALMIPII | ALMIP II root depth field |

```
Root depth file: none
```

## 7.4 Crop-Irrigation Parameters

**Incorporate crop information:** specifies the logical flag with which to turn on the inclusion of crop information and also to allow the user to enter additional options that can ensure crop, landcover, and irrigation features are agreement.

```
Incorporate crop information: .false.
```

**Crop type data source:** specifies the crop type map dataset source to be read in. Current landcover source options include:

| Value      | Description                                                                           |
|------------|---------------------------------------------------------------------------------------|
| UMDCROPMAP | UMD+CROPMAP crop type map. For more info, please refer to Ozdogan et al. (2010; JHM). |
| Monfreda08 | FAOSTAT05 crop type maps. For more info, please refer to Monfreda et al. (2008).      |
| CONSTANT   | Ability to set a constant crop type for a set classification.                         |

```
Crop type data source: "none"
```

**Crop classification:** specifies the crop classification system used to determine the range of crops indexed for a particular crop library source.

| Value     | Description                                                       |
|-----------|-------------------------------------------------------------------|
| none      | Data is on same grid as LIS output domain                         |
| CROPMAP   | 19 classes; named by Ozdogan et al.(2010), used Leff et al.(2004) |
| FAOSTAT01 | 19 classes; Used by Leff et al.(2004), considered obsolete        |
| FAOSTAT05 | 175 classes; Used by Monfreda et al. (2008)                       |

```
Crop classification: "FAOSTAT01"
```

**Crop library directory:** specifies the source of the crop library and inventory of crop classes, related to the “Crop classification:” entry (see above).

```
Crop library directory: "../LS_PARAMETERS/crop_params/Crop.Library.Files/"
```

**Assign crop value type:** specifies the type of crop presence, such as a “single” crop or “multiple” crops given within a gridcell. Currently, only the “single” option is supported.

```
Assign crop value type: "none"
```

**Assign single crop value:** specifies whether to assign a single crop value from an actual crop library inventory, such as FAOSTAT01, which is also known as the CROPMAP classification used in Ozdogan et al. (2010). By turning on this option (.true.), you can specify what type of crop you want to assign, like “maize” to the user-specified option, **Default crop type:**. If “maize” was entered, then wherever the landcover map indicated a generic “cropland”, the crop type field would be given a dominant “maize” type.

| Value   | Description                                                     |
|---------|-----------------------------------------------------------------|
| .false. | Do not assign a single crop class to the crop type field.       |
| .true.  | Assign a single crop type, like “maize” to the crop type field. |

```
Assign single crop value: .true.
```

**Default crop type:** specifies the default crop type that the user can enter and can be used in conjunction with assigning a single crop type value (see above).

```
Default crop type: "maize"
```

**Crop type file:** specifies the location of a crop type file. This file contains different crop types that can be used in conjunction with a selected land cover map (as above).

```
Crop type file: ./irrigation/conus_modis/UMD_N125C19.1gd4r
```

**Crop map spatial transform:** indicates which spatial transform (i.e., upscale or downscale) type is to be applied to a crop type map. Options include:

| Value | Description                                                    |
|-------|----------------------------------------------------------------|
| none  | Data is on same grid as LIS output domain                      |
| mode  | Upscale by selecting dominant type for each gridcell           |
| tile  | Read in tiled data or upscale by estimating gridcell fractions |

**NOTE:** LIS-7 will be expecting ‘mode’ or dominant crop type per gridcell at this time. Future versions will include landcover-crop tile options.

```
Crop map spatial transform: mode
```

**Irrigation type data source:** specifies the irrigation method type dataset source to be read in. Current source options include:

| Value | Description                       |
|-------|-----------------------------------|
| GRIPC | Irrigation map, by Salmon (2013). |

```
Irrigation type data source: "none"
```

**Irrigation type map:** specifies the location of an irrigation type file. This file contains different irrigation categories (types) that can be used in conjunction with an irrigation fraction map.

A special land-use/irrigation-related map, known as the Global Rain-Fed, Irrigated, and Paddy Croplands (GRIPC) Dataset (Salmon, 2013), has also been implemented as an option to LDT. Currently, no models in LIS utilize this map but opportunities exist for the user community to utilize for their landcover and irrigation modeling needs.

```
Irrigation type map: .../LS_PARAMETERS/irrigation/irrigtype_map.bin
```

**Irrigation type spatial transform:** indicates which spatial transform (i.e., upscale or downscale) type is to be applied to irrigation-related maps. Options include:

| Value    | Description                                                    |
|----------|----------------------------------------------------------------|
| none     | Data is on same grid as LIS output domain                      |
| mode     | Upscale by selecting dominant type for each gridcell           |
| neighbor | Use nearest neighbor to select closest value                   |
| tile     | Read in tiled data or upscale by estimating gridcell fractions |

|                                         |
|-----------------------------------------|
| Irrigation type spatial transform: mode |
|-----------------------------------------|

**Irrigation fraction data source:** specifies the irrigation method type dataset source to be read in. Current source options include:

| Value    | Description                                               |
|----------|-----------------------------------------------------------|
| MODIS_OG | Irrigation area fraction map by Ozdogan and Gutman (2008) |
| GRIPC    | Irrigation area fraction map by Salmon (2013)             |

|                                         |
|-----------------------------------------|
| Irrigation fraction data source: "none" |
|-----------------------------------------|

**Irrigation fraction map:** specifies the location of an irrigation fraction map file. This file contains irrigation fraction (gridcell-based) that can be used in conjunction with an irrigation type map.

|                                                                   |
|-------------------------------------------------------------------|
| Irrigation fraction map: ../irrigation/irrig.percent.eighth.1gd4r |
|-------------------------------------------------------------------|

**Irrigation fraction spatial transform:** indicates which spatial transform (i.e., upscale or downscale) type is to be applied to irrigation-related maps. Options include:

| Value   | Description                                   |
|---------|-----------------------------------------------|
| none    | Data is on same grid as LIS output domain     |
| average | Upscale by averaging values for each gridcell |

|                                             |
|---------------------------------------------|
| Irrigation fraction spatial transform: none |
|---------------------------------------------|

## 7.5 Soil Parameters

Soils maps

**Sand fraction map:** specifies the sand fraction map file.

**Clay fraction map:** specifies the clay fraction map file.

**Silt fraction map:** specifies the silt map file.

**Porosity data source:** specifies the soil porosity dataset source to be read in. Current source options include:

| Value    | Description                                          |
|----------|------------------------------------------------------|
| FAO      | LIS-team produced soil porosity data source.         |
| CLSMF2.5 | Similar to the above option but for CLSM F2.5 model. |
| CONSTANT | User can select a constant value.                    |

**Porosity map:** specifies porosity map file.

**Soildepth data source:** specifies the soildepth dataset source to be read in. Current source option is:

| Value   | Description                     |
|---------|---------------------------------|
| ALMIPII | ALMIPII soil depth data source. |

**Soil depth map:** specifies the soil depth map file.

**Saturated matric potential map:** specifies saturated matric potential map file.

**Saturated hydraulic conductivity map:** specifies saturated hydraulic conductivity map file.

**b parameter map:** specifies b parameter map file.

```
Sand fraction map: ../input/25KM/sand_FA0.1gd4r
Clay fraction map: ../input/25KM/clay_FA0.1gd4r
Silt fraction map: ../input/25KM/silt_FA0.1gd4r
Porosity data source: none
Porosity map:
Saturated matric potential map:
Saturated hydraulic conductivity map:
b parameter map:
```

**Soil fraction data source:** specifies the source of the soil fraction dataset. Options include:

| Value       | Description                                          |
|-------------|------------------------------------------------------|
| none        | No soil fraction data source                         |
| FAO         | FAO soil fraction percentage fields                  |
| STATSGO_LIS | LIS-team derived STATSGO v1 soil fraction fields     |
| ALMIPII     | ALMIP II soil fraction percentage fields             |
| CONSTANT    | If user wants to set a constant soil fraction values |

|                            |     |
|----------------------------|-----|
| Soil fraction data source: | FAO |
|----------------------------|-----|

**Soil fraction number of bands:** specifies the number of soil fraction bins to turn on soil fraction tiling capability.

|                                |   |
|--------------------------------|---|
| Soil fraction number of bands: | 1 |
|--------------------------------|---|

**Soils spatial transform:** indicates which spatial transform (i.e., upscale or downscale) type is to be applied to the soils maps. Options include:

| Value           | Description                                                    |
|-----------------|----------------------------------------------------------------|
| none            | Data is on same grid as LIS output domain                      |
| average         | Upscale by averaging values for each gridcell                  |
| neighbor        | Reinterpolate by selecting nearest gridcell neighbor           |
| bilinear        | Reinterpolate by using bilinear interpolation                  |
| budget-bilinear | Reinterpolate by using conservative, budget-bilinear           |
| tile            | Read in tiled data or upscale by estimating gridcell fractions |

|                          |         |
|--------------------------|---------|
| Soils spatial transform: | average |
|--------------------------|---------|

**Soils map projection:** specifies the projection of the soils map data.

**Soils fill option:** specifies the general soil data (e.g., fractions) fill option. Options include:

| Value    | Description                                |
|----------|--------------------------------------------|
| none     | Do not apply missing value fill routines   |
| neighbor | Use nearest neighbor to fill missing value |

By selecting the soils fill option, neighbor, this activates the need to enter values for the Soils fill radius and fill value, as shown below. If a porosity map is read in and the soils fill option is set to neighbor, the user can then enter a fill value for porosity to ensure mask-parameter agreement.

**Soils fill radius:** specifies the radius with which to search for nearby value(s) to help fill the missing value.

**Soils fill value:** indicates which soils value to be used if an arbitrary value fill is needed. (For example, when the landmask indicates a land point but no existing soils value, a value of 0.33 could be assigned if no nearest neighbor values exists to fill).

**Porosity fill value:** indicates which porosity value to be used if an arbitrary value fill is needed. (For example, when the landmask indicates a land point but no existing porosity value, a value of 0.30 could be assigned if no nearest neighbor values exists to fill).

```
Soils fill option: neighbor
Soils fill radius: 3
Soils fill value: 0.33
Porosity fill value: 0.30
```

If the map projection of parameter data is specified to be lat/lon, the following configuration should be used for specifying soils data, if the data source option has a “\_LIS” in the name. See Appendix B for more details about setting these values.

```
Soils map projection: latlon
Soils lower left lat: -59.87500
Soils lower left lon: -179.87500
Soils upper right lat: 89.87500
Soils upper right lon: 179.87500
Soils resolution (dx): 0.2500
Soils resolution (dy): 0.2500
```

**Hydrologic soil group source:** specifies the hydrological soil group (HSG) data source. Options include:

| Value     | Description                |
|-----------|----------------------------|
| none      | No HSG data source         |
| STATSGOv1 | STATSGO v1 HSG data source |

```
Hydrologic soil group source: STATSGOv1
```

**Hydrologic soil group map:** specifies the path and filename for the HSG input file.

```
Hydrologic soil group map: ./input/STATSGO_v1/hsgpct.bsq
```

**Soil texture data source:** specifies the soil texture dataset source to be read in.

Current soil texture source options include:

| Value             | Description                                                                                                                                                                          |
|-------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| STATSGOFAO_Native | The blended STATSGOv1 and FAO soil texture map. See: <a href="http://www.ral.ucar.edu/research/land/technology/lsm.php">http://www.ral.ucar.edu/research/land/technology/lsm.php</a> |
| STATSGOFAO_LIS    | Similar dataset as to the above one but processed by LIS-team.                                                                                                                       |
| FAO               | FAO or Reynolds et al. (1999) soil texture map.                                                                                                                                      |
| ZOBLER_GFS        | Similar to above but on a GFS run domain.                                                                                                                                            |
| STATSGOv1         | The STATSGOv1-only soil texture map.                                                                                                                                                 |
| CONSTANT          | User can set a constant soil texture class.                                                                                                                                          |

```
Soil texture data source: "STATSGOFAO_Native"
```

**Soil texture map:** specifies the soil texture file.

**Soil texture spatial transform:** indicates which spatial transform (i.e., upscale or downscale) type is to be applied to the soil texture map. Options include:

| Value    | Description                                                    |
|----------|----------------------------------------------------------------|
| none     | Data is on same grid as LIS output domain                      |
| mode     | Upscale by selecting dominant type for each gridcell           |
| neighbor | Upscale by using nearest valid value for each gridcell         |
| tile     | Read in tiled data or upscale by estimating gridcell fractions |

```
Soil texture map: ../input/25KM/soiltexture_STATSGO-FAO.1gd4r
Soil texture spatial transform: none
```

**Soil texture map projection:** specifies the projection of the soil texture map data.

**Soil texture fill option:** specifies the soil texture data fill option. Options include:

| Value    | Description                                |
|----------|--------------------------------------------|
| none     | Do not apply missing value fill routines   |
| neighbor | Use nearest neighbor to fill missing value |

**Soil texture fill value:** indicates which soil texture value to be used if an arbitrary value fill is needed. (For example, when the landmask indicates a land point but no existing soil texture value, a value of 6 could be assigned if no nearest neighbor values exists to fill).

**Soil texture fill radius:** specifies the radius with which to search for nearby value(s) to help fill in the missing value.

```
Soil texture fill option: neighbor
Soil texture fill radius: 3.
Soil texture fill value: 6.
```

If the map projection of parameter data is specified to be lat/lon, the following configuration should be used for specifying soil texture data, if the data source option has a “.LIS” in the name. See Appendix B for more details about setting these values.

```
Soil texture map projection: latlon
Soil texture lower left lat: -59.87500
Soil texture lower left lon: -179.87500
Soil texture upper right lat: 89.87500
Soil texture upper right lon: 179.87500
Soil texture resolution (dx): 0.2500
Soil texture resolution (dy): 0.2500
```

**Soil color map projection:** specifies the projection of the soil color map data.

**Soil color data source:** specifies the soil color data source. Current option is: FAO

**Soil color map:** specifies the soil color map file. This soil map is mainly used by the Community Land Model (version 2).

**Soil color spatial transform:** indicates which spatial transform (i.e., upscale or downscale) type is to be applied to the soil color map. Options include:

| Value    | Description                                          |
|----------|------------------------------------------------------|
| none     | Data is on same grid as LIS output domain            |
| mode     | Upscale by selecting dominant type for each gridcell |
| neighbor | Reinterpolate by selecting nearest gridcell neighbor |

|                               |      |
|-------------------------------|------|
| Soil color data source:       | none |
| Soil color map:               |      |
| Soil color spatial transform: | none |

If the map projection of parameter data is specified to be lat/lon, the following configuration should be used for specifying soil color data, data source option “FAO” or has a “\_LIS” in the name. See Appendix B for more details about setting these values.

|                             |            |
|-----------------------------|------------|
| Soil color map projection:  | latlon     |
| Soil color lower left lat:  | -59.87500  |
| Soil color lower left lon:  | -179.87500 |
| Soil color upper right lat: | 89.87500   |
| Soil color upper right lon: | 179.87500  |
| Soil color resolution (dx): | 0.2500     |
| Soil color resolution (dy): | 0.2500     |

## 7.6 Topography Parameters

**Elevation data source:** specifies the elevation dataset source to be read in.

**Slope data source:** specifies the slope dataset source to be read in.

**Aspect data source:** specifies the aspect dataset source to be read in.

**Curvature data source:** specifies the curvature dataset source to be read in.

Current options include:

| Value          | Description                                                                                                                                                        |
|----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| GTOPO30_Native | The GTOPO30 elevation map native source. See:<br><a href="http://edcftp.cr.usgs.gov/pub/data/gtopo30/global">http://edcftp.cr.usgs.gov/pub/data/gtopo30/global</a> |
| GTOPO30_LIS    | Similar dataset as to the above one but processed by LIS-team.                                                                                                     |
| GTOPO30_GFS    | Similar dataset as to the above but on GFS grid.                                                                                                                   |
| SRTM_Native    | The SRTM elevation map native source. See:<br><a href="http://dds.cr.usgs.gov/srtm/version2_1/SRTM30">http://dds.cr.usgs.gov/srtm/version2_1/SRTM30</a>            |
| SRTM_LIS       | Similar dataset as to the above one but processed by LIS-team.                                                                                                     |
| CONSTANT       | User can set a constant elevation, slope or aspect class.                                                                                                          |

```
Elevation data source: "SRTM_Native"
Slope data source: "SRTM_Native"
Aspect data source: "SRTM_Native"
Curvature data source: "SRTM_Native"
```

**Elevation number of bands:** specifies the number of elevation bands or bins to turn on elevation tiling capability.

**Slope number of bands:** specifies the number of slope bands or bins to turn on slope tiling capability.

**Aspect number of bands:** specifies the number of aspect bands or bins to turn on aspect tiling capability.

**Curvature number of bands:** specifies the number of curvature bands or bins to turn on curvature tiling capability.

```
Elevation number of bands: 1
Slope number of bands: 1
Aspect number of bands: 1
Curvature number of bands: 1
```

### Topography maps

**Elevation map:** specifies the elevation of the LIS grid. If the elevation map type selected is SRTM\_Native, then the elevation file entry is actually just the directory path, which contains the tiled SRTM elevation files.

**Slope map:** specifies the slope of the LIS grid. If the slope map type selected is SRTM\_Native, then the file entry is actually just the directory path, which contains the tiled SRTM elevation files.

**Aspect map:** specifies the aspect of the LIS grid. If the aspect map type selected is SRTM\_Native, then the file entry is actually just the directory path, which contains the tiled SRTM elevation files.

**Curvature map:** specifies the curvature of the LIS grid.

|                |                                   |
|----------------|-----------------------------------|
| Elevation map: | ./input/25KM/elev_GTOPO30.1gd4r   |
| Slope map:     | ./input/25KM/slope_GTOPO30.1gd4r  |
| Aspect map:    | ./input/25KM/aspect_GTOPO30.1gd4r |
| Curvature map: | ./input/25KM/curv_GTOPO30.1gd4r   |

**Elevation fill option:** specifies the elevation data fill option. Options include:

|          |                                            |
|----------|--------------------------------------------|
| Value    | Description                                |
| none     | Do not apply missing value fill routines   |
| neighbor | Use nearest neighbor to fill missing value |

**Elevation fill value:** indicates which elevation value to be used if an arbitrary value fill is needed. (For example, when the landmask indicates a land point but no existing elevation value, a value of 100(m) could be assigned if no nearest neighbor values exists to fill).

**Elevation fill radius:** specifies the radius with which to search for nearby value(s) to help fill in the missing value.

|                        |          |
|------------------------|----------|
| Elevation fill option: | neighbor |
| Elevation fill radius: | 2.       |
| Elevation fill value:  | 100.     |

**Slope fill option:** specifies the slope data fill option. Options include:

|          |                                            |
|----------|--------------------------------------------|
| Value    | Description                                |
| none     | Do not apply missing value fill routines   |
| neighbor | Use nearest neighbor to fill missing value |

**Slope fill value:** indicates which slope value to be used if an arbitrary value fill is needed. (For example, when the landmask indicates a land point but no existing slope value, an value of 0.1 could be assigned if no nearest neighbor values exists to fill).

**Slope fill radius:** specifies the radius with which to search for nearby value(s) to help fill in the missing value.

|                    |          |
|--------------------|----------|
| Slope fill option: | neighbor |
| Slope fill radius: | 2.       |
| Slope fill value:  | 0.1      |

**Aspect fill option:** specifies the aspect data fill option. Options include:

| Value    | Description                                |
|----------|--------------------------------------------|
| none     | Do not apply missing value fill routines   |
| neighbor | Use nearest neighbor to fill missing value |

**Aspect fill value:** indicates which aspect value to be used if an arbitrary value fill is needed. (For example, when the landmask indicates a land point but no existing aspect value, an value of 2.0 could be assigned if no nearest neighbor values exists to fill).

**Aspect fill radius:** specifies the radius with which to search for nearby value(s) to help fill in the missing value.

|                     |          |
|---------------------|----------|
| Aspect fill option: | neighbor |
| Aspect fill radius: | 2.       |
| Aspect fill value:  | 2.0      |

**Topography map projection:** specifies the projection of the topography map data.

**Topography spatial transform:** indicates which spatial transform (i.e., upscale or downscale) type is to be applied to the topographic map. Options include:

| Value           | Description                                                    |
|-----------------|----------------------------------------------------------------|
| none            | Data is on same grid as LIS output domain                      |
| average         | Upscale by averaging values for each gridcell                  |
| neighbor        | Reinterpolate by selecting nearest gridcell neighbor           |
| bilinear        | Reinterpolate by using bilinear interpolation                  |
| budget-bilinear | Reinterpolate by using conservative, budget-bilinear           |
| tile            | Read in tiled data or upscale by estimating gridcell fractions |

|                               |      |
|-------------------------------|------|
| Topography spatial transform: | tile |
|-------------------------------|------|

This section should also specify the domain specifications of the topography data. If the map projection of parameter data is specified to be lat/lon, the

following configuration should be used for specifying topography data, especially if the data source option has a “\_LIS” in the name. See Appendix B for more details about setting these values.

|                             |            |
|-----------------------------|------------|
| Topography map projection:  | latlon     |
| Topography lower left lat:  | -59.87500  |
| Topography lower left lon:  | -179.87500 |
| Topography upper right lat: | 89.87500   |
| Topography upper right lon: | 179.87500  |
| Topography resolution (dx): | 0.2500     |
| Topography resolution (dy): | 0.2500     |

## 7.7 LSM-specific Parameters

### Albedo maps

**Albedo data source:** specifies the albedo climatology map dataset source to be read in. Current source options include:

| Value       | Description                                         |
|-------------|-----------------------------------------------------|
| NCEP_Native | Native monthly NCEP albedo files.                   |
| NCEP_LIS    | Similar to the above option but LIS-team processed. |
| CONSTANT    | User can select a constant value.                   |

**Albedo map:** specifies the path of the climatology based albedo files. The climatology albedo data files have the following naming convention: <directory>/<file header>.<tag>.1gd4r The tag should be either sum, win, spr, or aut depending on the season, or the tag should represent the month (such as jan, feb, mar, etc.). The file header can be anything (such as alb1KM). The albedo field is used by Noah LSM versions.

**Albedo climatology interval:** specifies the frequency of the albedo climatology in months.

| Value     | Description                        |
|-----------|------------------------------------|
| monthly   | Monthly interval for albedo files  |
| quarterly | Seasonal interval for albedo files |

**Albedo spatial transform:** indicates which spatial transform (i.e., upscale or downscale) type is to be applied to the albedo maps. Options include:

| Value           | Description                                          |
|-----------------|------------------------------------------------------|
| none            | Data is on same grid as LIS output domain            |
| average         | Upscale by averaging values for each gridcell        |
| neighbor        | Reinterpolate by selecting nearest gridcell neighbor |
| bilinear        | Reinterpolate by using bilinear interpolation        |
| budget-bilinear | Reinterpolate by using conservative, budget-bilinear |

|                              |                           |
|------------------------------|---------------------------|
| Albedo data source:          | NCEP_LIS                  |
| Albedo map:                  | ../input/25KM/albedo_NCEP |
| Albedo climatology interval: | monthly                   |
| Albedo spatial transform:    | none                      |

If selecting the Catchment LSM (F2.5 version), the model requires the near infrared (NIR) and visible (VIS) albedo factor files, as shown below for example. This particular albedo parameter set is currently only available for the Catchment LSM Fortuna 2.5 (CLSMF2.5).

**Albedo NIR factor file:** specifies the NIR albedo factor file.

**Albedo VIS factor file:** specifies the VIS albedo factor file.

These albedo parameter subroutines can be found in the albedo directory.

|                         |                                               |
|-------------------------|-----------------------------------------------|
| Albedo NIR factor file: | ./GLDAS_1.0-deg/modis_scale_factor.albnf.clim |
| Albedo VIS factor file: | ./GLDAS_1.0-deg/modis_scale_factor.albvf.clim |

**Albedo fill option:** specifies the albedo data fill option. Options include:

| Value   | Description                              |
|---------|------------------------------------------|
| none    | Do not apply missing value fill routines |
| average | Use average to fill missing value        |

**Albedo fill value:** indicates which albedo value to be used if an arbitrary value fill is needed. (For example, when the landmask indicates a land point but no existing albedo value, a value of 0.12 could be assigned if no nearest neighbor values exists to fill).

**Albedo fill radius:** specifies the radius with which to search for nearby value(s) to help fill in the missing value.

|                     |         |
|---------------------|---------|
| Albedo fill option: | average |
|---------------------|---------|

|                            |      |
|----------------------------|------|
| <b>Albedo fill radius:</b> | 2.   |
| <b>Albedo fill value:</b>  | 0.12 |

If the map projection of parameter data is specified to be lat/lon, the following configuration should be used for specifying albedo data where the albedo data source option has a “\_LIS” in the name. See Appendix B for more details about setting these values.

|                                |            |
|--------------------------------|------------|
| <b>Albedo map projection:</b>  | latlon     |
| <b>Albedo lower left lat:</b>  | -59.87500  |
| <b>Albedo lower left lon:</b>  | -179.87500 |
| <b>Albedo upper right lat:</b> | 89.87500   |
| <b>Albedo upper right lon:</b> | 179.87500  |
| <b>Albedo resolution (dx):</b> | 0.2500     |
| <b>Albedo resolution (dy):</b> | 0.2500     |

**Max snow albedo data source:** specifies the maximum snow albedo dataset source to be read in. Current source options include:

| Value         | Description                                         |
|---------------|-----------------------------------------------------|
| NCEP_Native   | Native NCEP maximum snow albedo source.             |
| NCEP_LIS      | Similar to the above option but LIS-team processed. |
| NCEP_GFS      | Similar to the above option but on GFS grid.        |
| SACHTET.3.5.6 | Max snow albedo specific to the SAC-HTET model.     |
| CONSTANT      | User can select a constant value.                   |

**Max snow albedo map:** specifies the map file containing data with the static upper bound of the snow albedo. The albedo field is used by all Noah LSM and RDHM-SAC LSM versions.

**Max snow albedo spatial transform:** indicates which spatial transform (i.e., upscale or downscale) type is to be applied to the maximum snow albedo map. Options include:

| Value           | Description                                          |
|-----------------|------------------------------------------------------|
| none            | Data is on same grid as LIS output domain            |
| average         | Upscale by averaging values for each gridcell        |
| neighbor        | Reinterpolate by selecting nearest gridcell neighbor |
| bilinear        | Reinterpolate by using bilinear interpolation        |
| budget-bilinear | Reinterpolate by using conservative, budget-bilinear |

|                                     |          |
|-------------------------------------|----------|
| <b>Max snow albedo data source:</b> | NCEP_LIS |
|-------------------------------------|----------|

```
Max snow albedo map: ./input/25KM/mxsnoalb_MODIS.1gd4r
Max snow albedo spatial transform: none
```

**Max snow albedo fill option:** specifies the max snow albedo data fill option. Options include:

| Value   | Description                              |
|---------|------------------------------------------|
| none    | Do not apply missing value fill routines |
| average | Use average to fill missing value        |

**Max snow albedo fill value:** indicates which max snow albedo value to be used if an arbitrary value fill is needed. (For example, when the landmask indicates a land point but no existing snow albedo value, an value of 0.42 could be assigned if no nearest neighbor values exists to fill).

**Max snow albedo fill radius:** specifies the radius with which to search for nearby value(s) to help fill in the missing value.

```
Max snow albedo fill option: average
Max snow albedo fill radius: 3.
Max snow albedo fill value: 0.42
```

If the map projection of parameter data is specified to be lat/lon, the following configuration should be used for specifying max snow albedo data, where the max snow albedo albedo data source option has a “\_LIS” in the name. See Appendix B for more details about setting these values.

```
Max snow albedo map projection: latlon
Max snow albedo lower left lat: -59.87500
Max snow albedo lower left lon: -179.87500
Max snow albedo upper right lat: 89.87500
Max snow albedo upper right lon: 179.87500
Max snow albedo resolution (dx): 0.2500
Max snow albedo resolution (dy): 0.2500
```

## Greenness fraction maps

Greenness vegetation fraction is considered the horizontal greenness fraction represented for a model gridcell. This parameter is used in the LSMs: all Noah LSMs, RDHM-SAC, Catchment F2.5.

**Greenness data source:** specifies the greenness fraction climatology dataset source to be read in. Current source options include:

| Value         | Description                                          |
|---------------|------------------------------------------------------|
| NCEP_Native   | Native NCEP monthly greenness climatology source.    |
| NCEP_LIS      | Similar to the above option but LIS-team processed.  |
| CLSMF2.5      | Similar to the above option but for CLSM F2.5 model. |
| SACHTET.3.5.6 | Similar to the above option but for SAC-HTET model.  |
| CONSTANT      | User can select a constant value.                    |

**Greenness fraction map:** specifies the source of the climatology based gfrac files. The climatology greenness data files have the following naming convention: <directory>/<file header>.<tag>.1gd4r. The tag should represent the month (such as jan, feb, mar, etc.). The file header can be anything (such as green1KM).

**Greenness climatology interval:** specifies the frequency of the greenness climatology in months. Only current option is: “monthly”.

**Calculate min-max greenness fraction:** specifies a logical flag option to offer the user the ability to calculate minimum and maximum greenness fraction values from a given climatology (e.g., monthly). Acceptable values are:

| Value   | Description                                                  |
|---------|--------------------------------------------------------------|
| .false. | Read in min and max greenness fraction value maps            |
| .true.  | Calculate greenness fraction from greenness climatology maps |

**Greenness maximum map:** specifies the file of the climatological maximum greenness data from the monthly greenness files.

**Greenness minimum map:** specifies the file of the climatological minimum greenness data from the monthly greenness files.

**Greenness spatial transform:** indicates which spatial transform (i.e., upscale or downscale) type is to be applied to the greenness maps. Options include:

| Value           | Description                                          |
|-----------------|------------------------------------------------------|
| none            | Data is on same grid as LIS output domain            |
| average         | Upscale by averaging values for each gridcell        |
| neighbor        | Reinterpolate by selecting nearest gridcell neighbor |
| bilinear        | Reinterpolate by using bilinear interpolation        |
| budget-bilinear | Reinterpolate by using conservative, budget-bilinear |

|                        |          |
|------------------------|----------|
| Greenness data source: | NCEP_LIS |
|------------------------|----------|

```

Greenness fraction map: ./input/25KM/gvf_NCEP
Greenness climatology interval: monthly
Calculate min-max greenness fraction: .true.
Greenness maximum map: ./input/25KM/gvf_NCEP.MAX.1gd4r
Greenness minimum map: ./input/25KM/gvf_NCEP.MIN.1gd4r
Greenness spatial transform: none

```

**Greenness fill option:** specifies the greenness fraction data fill option. Options include:

| Value   | Description                              |
|---------|------------------------------------------|
| none    | Do not apply missing value fill routines |
| average | Use average to fill missing value        |

**Greenness fill radius:** specifies the radius with which to search for nearby value(s) to help fill in the missing value.

**Greenness fill value:** indicates which greenness fraction value to be used if an arbitrary value fill is needed. (For example, when the landmask indicates a land point but no existing greenness value, a value of 0.2 could be assigned if exists to fill).

**Greenness maximum fill value:** indicates which maximum greenness fraction value to be used if an arbitrary value fill is needed.

**Greenness minimum fill value:** indicates which minimum greenness fraction value to be used if an arbitrary value fill is needed.

```

Greenness fill option: average
Greenness fill radius: 3
Greenness fill value: 0.20
Greenness maximum fill value: 0.80
Greenness minimum fill value: 0.05

```

If the map projection of parameter data is specified to be lat/lon, the following configuration should be used for specifying greenness data source, if the option has a “\_LIS” in the name. See Appendix B for more details about setting these values.

```

Greenness map projection: latlon
Greenness lower left lat: -59.87500
Greenness lower left lon: -179.87500

```

|                            |           |
|----------------------------|-----------|
| Greenness upper right lat: | 89.87500  |
| Greenness upper right lon: | 179.87500 |
| Greenness resolution (dx): | 0.2500    |
| Greenness resolution (dy): | 0.2500    |

LAI/SAI maps Leaf area index and stem area index maps are used to describe the vertical representation of leafy vegetation and the woody-branch areas within a given gridcell (respectively). LAI/SAI are used in the Community Land Model (CLM), Mosaic LSM, and Catchment LSM, version F2.5.

**LAI data source:** specifies the leaf area index (LAI) climatology dataset source to be read in. Current source options include:

| Value    | Description                                          |
|----------|------------------------------------------------------|
| AVHRR    | LIS-team produced monthly LAI climatology source.    |
| CLSMF2.5 | Similar to the above option but for CLSM F2.5 model. |
| CONSTANT | User can select a constant value.                    |

**SAI data source:** specifies the stem area index (SAI) climatology dataset source to be read in. Current source options include:

| Value    | Description                                       |
|----------|---------------------------------------------------|
| AVHRR    | LIS-team produced monthly SAI climatology source. |
| CONSTANT | User can select a constant value.                 |

**LAI map:** specifies the source of the climatology based LAI files. The climatology data files have the following naming convention: <directory>/<file header>.<tag>.1gd4r. The tag should represent the month (such as jan, feb, mar, etc.). The file header can be anything (such as avhrr\_lai\_1KM).

**SAI map:** specifies the source of the climatology based SAI files. The climatology data files have the following naming convention: <directory>/<file header>.<tag>.1gd4r. The tag should represent the month (such as jan, feb, mar, etc.). The file header can be anything (such as avhrr\_sai\_1KM).

**LAI/SAI climatology interval:** specifies the frequency of the LAI or SAI climatology in months. Current option is: “monthly”.

**Calculate min-max LAI:** specifies a logical flag option to offer the user the ability to calculate minimum and maximum LAI values from a given climatology (e.g., monthly). Acceptable values are:

| Value   | Description                             |
|---------|-----------------------------------------|
| .false. | Read in min and max LAI value maps      |
| .true.  | Calculate LAI from LAI climatology maps |

**LAI maximum map:** specifies the file of the climatological maximum LAI data from the monthly LAI files.

**LAI minimum map:** specifies the file of the climatological minimum LAI data from the monthly LAI files.

**LAI/SAI spatial transform:** indicates which spatial transform (i.e., upscale or downscale) type is to be applied to the LAI and SAI maps. Only “none” option works for the “AVHRR” or “CLSMF2.5” LAI data source entries. Other spatial options for the include:

| Value           | Description                                          |
|-----------------|------------------------------------------------------|
| none            | Data is on same grid as LIS output domain            |
| average         | Upscale by averaging values for each gridcell        |
| neighbor        | Reinterpolate by selecting nearest gridcell neighbor |
| bilinear        | Reinterpolate by using bilinear interpolation        |
| budget-bilinear | Reinterpolate by using conservative, budget-bilinear |

```
LAI data source: CLSMF2.5
LAI map: ../input/25KM/avhrr_lai_nldas
SAI map: ../input/25KM/avhrr_sai_nldas
Calculate min-max LAI: .false.
LAI maximum map: ../input/CLSMF2.5/clsmf2.5_maxlai.1gd4r
LAI minimum map: ../input/CLSMF2.5/clsmf2.5_minlai.1gd4r
LAI/SAI climatology interval: monthly
LAI/SAI spatial transform: none
```

**LAI/SAI fill option:** specifies the LAI/SAI data fill option. Options include:

| Value   | Description                              |
|---------|------------------------------------------|
| none    | Do not apply missing value fill routines |
| average | Use average to fill missing value        |

**LAI/SAI fill radius:** specifies the radius with which to search for nearby value(s) to help fill in the missing value.

**LAI fill value:** indicates which LAI value to be used if an arbitrary value fill is needed. (For example, when the landmask indicates a land point but no existing LAI value, a value of 1 could be assigned if exists to fill).

**LAI maximum fill value:** indicates which maximum LAI value to be used if an arbitrary value fill is needed.

**LAI minimum fill value:** indicates which minimum LAI value to be used if

an arbitrary value fill is needed.

**SAI fill value:** indicates which SAI value to be used if an arbitrary value fill is needed.

```
LAI/SAI fill option: average
LAI/SAI fill radius: 3
LAI fill value: 1
SAI fill value: 0.5
LAI maximum fill value: 4
LAI minimum fill value: 1
```

If the map projection of parameter data is specified to be lat/lon, the following configuration should be used for specifying LAI/SAI data, if the data source option has a “\_LIS” in the name. See Appendix B for more details about setting these values.

```
LAI/SAI map projection: latlon
LAI/SAI lower left lat: -59.87500
LAI/SAI lower left lon: -179.87500
LAI/SAI upper right lat: 89.87500
LAI/SAI upper right lon: 179.87500
LAI/SAI resolution (dx): 0.2500
LAI/SAI resolution (dy): 0.2500
```

**Slope type data source:** specifies the slope type index dataset source to be read in. Current source options include:

| Value       | Description                                         |
|-------------|-----------------------------------------------------|
| NCEP_Native | Native NCEP slope type derived map source.          |
| NCEP_LIS    | Similar to the above option but LIS-team processed. |
| NCEP_GFS    | Similar to the above option but on a GFS grid type. |
| CONSTANT    | User can select a constant value.                   |

**Slope type map:** specifies the slope type index as used in all Noah LSM versions.

**Slope type spatial transform:** indicates which spatial transform (i.e., upscale or downscale) type is to be applied to the soils maps. Options include:

| Value    | Description                                              |
|----------|----------------------------------------------------------|
| none     | Data is on same grid as LIS output domain                |
| mode     | Upscale by selecting dominant type for each gridcell     |
| neighbor | Use nearest neighbor to select nearest gridcell neighbor |

```

Slope type data source: NCEP_LIS
Slope type map: ../input/25KM/slopetype_NCEP.1gd4r
Slope type spatial transform: none

```

**Slope type fill option:** specifies the slope type data fill option. Options include:

| Value    | Description                                |
|----------|--------------------------------------------|
| none     | Do not apply missing value fill routines   |
| neighbor | Use nearest neighbor to fill missing value |

**Slope type fill value:** indicates which slope type value to be used if an arbitrary value fill is needed. (For example, when the landmask indicates a land point but no existing slope type value, an index value of 1 could be assigned if no nearest neighbor values exists to fill).

**Slope type fill radius:** specifies the radius with which to search for nearby value(s) to help fill in the missing value.

```

Slope type fill option: neighbor
Slope type fill radius: 2.
Slope type fill value: 1.

```

If the map projection of parameter data is specified to be lat/lon, the following configuration should be used for specifying slope type data, if the data source option has a “\_LIS” in the name. See Appendix B for more details about setting these values.

```

Slope type map projection: latlon
Slope type lower left lat: -59.87500
Slope type lower left lon: -179.87500
Slope type upper right lat: 89.87500
Slope type upper right lon: 179.87500
Slope type resolution (dx): 0.2500
Slope type resolution (dy): 0.2500

```

**Bottom temperature data source:** specifies the bottom temperature dataset source to be read in. Current source options include:

| Value    | Description                                         |
|----------|-----------------------------------------------------|
| ISLSCP1  | Native (NCEP) ISLSCP1 temperature derived map.      |
| NCEP_LIS | Similar to the above option but LIS-team processed. |
| NCEP_GFS | Similar to the above option but on a GFS grid type. |
| CONSTANT | User can select a constant value.                   |

**Bottom temperature map:** specifies the bottom boundary temperature data. This parameter is currently required by the Noah LSM versions and the recently added RDHM-SAC/Snow-17 models.

**Bottom temperature spatial transform:** indicates which spatial transform (i.e., upscale or downscale) type is to be applied to the bottom temperature map. Options include:

| Value           | Description                                   |
|-----------------|-----------------------------------------------|
| none            | Data is on same grid as LIS output domain     |
| average         | Upscale by averaging values for each gridcell |
| neighbor        | Nearest neighbor scheme                       |
| bilinear        | bilinear scheme                               |
| budget-bilinear | conservative scheme                           |

```
Bottom temperature data source: NCEP_LIS
Bottom temperature map: ../input/25KM/tbot_GDAS_6YR_CLIM.1gd4r
Bottom temperature spatial transform: none
```

**Bottom temperature fill option:** specifies the bottom boundary temperature data fill option. Options include:

| Value    | Description                                |
|----------|--------------------------------------------|
| none     | Do not apply missing value fill routines   |
| average  | Averaging values for each missing value    |
| neighbor | Use nearest neighbor to fill missing value |

**Bottom temperature fill value:** indicates which bottom soil temperature value to be used if an arbitrary value fill is needed. (For example, when the landmask indicates a land point but no existing bottom temperature field, a value of 287 K could be assigned if no nearest neighbor values exists to fill).

**Bottom temperature fill radius:** specifies the radius with which to search for nearby value(s) to help fill in the missing value.

```
Bottom temperature fill option: neighbor
Bottom temperature fill radius: 3.
Bottom temperature fill value: 287.0
```

**Bottom temperature topographic downscaling:** specifies the option with which to adjust bottom temperature field due to topographic impacts.

| Value      | Description                                                           |
|------------|-----------------------------------------------------------------------|
| none       | No topographic/elevation adjustment made to parameter data            |
| lapse-rate | Adjust (or downscale) bottom temperature using lapse-rate correction. |

```
Bottom temperature topographic downscaling: none
```

If the map projection of parameter data is specified to be lat/lon, the following configuration should be used for specifying bottom temperature parameter data, if the data source option has a “\_LIS” in the name. See Appendix B for more details about setting these values.

```
Bottom temperature map projection: latlon
Bottom temperature lower left lat: -59.87500
Bottom temperature lower left lon: -179.87500
Bottom temperature upper right lat: 89.87500
Bottom temperature upper right lon: 179.87500
Bottom temperature resolution (dx): 0.2500
Bottom temperature resolution (dy): 0.2500
```

**Noah-MP PBL Height Value:** specifies the option which to set the planetary boundary layer height (PBLH) value for the Noah-MP (3.6) model.

```
Noah-MP PBL Height Value: 900. # in meters
```

Potential Evapotranspiration (PET) maps

**PET directory:** specifies the source of the monthly climatology based PET files. The climatology data files have the following naming convention: <directory>/<file header>.<tag>.1gd4r. The tag should be represent the month (such as JAN,

FEB, MAR, etc.). The file header can be anything (such as avhrr\_pet\_1KM). Currently, this parameter is used only with the RDHM-SAC model.

**PET adjustment factor directory:** specifies the source of the m monthly climatology-based PET adjustment factor files. The climatology data files have the following naming convention: <directory>/<file header>.<tag>.1gd4r. The tag should represent the month (such as JAN, FEB, MAR, etc.). The file header can be anything (such as avhrr\_petadj\_1KM).

**PET climatology interval:** specifies the frequency of the PET climatology in months. Current option is: “monthly”.

**PET spatial transform:** indicates which spatial transform (i.e., upscale or downscale) type is to be applied to the PET maps. Options include:

| Value | Description                                                     |
|-------|-----------------------------------------------------------------|
| none  | Data is on same grid as LIS output domain (only option for now) |

```
PET directory: .../input/25KM/sachtet_pet
PET adjustment factor directory: .../input/25KM/sachtet_petadj
PET climatology interval: monthly
PET spatial transform: none
```

**PET fill option:** specifies the PET climatology data fill option. Options include:

| Value   | Description                              |
|---------|------------------------------------------|
| none    | Do not apply missing value fill routines |
| average | Use average to fill missing value        |

**PET fill radius:** specifies the radius with which to search for nearby value(s) to help fill in the missing value.

**PET fill value:** indicates which PET value to be used if an arbitrary value fill is needed. (For example, when the landmask indicates a land point but no existing PET value, a value of 1 could be assigned if exists to fill.)

```
PET fill option: average
PET fill radius: 3
PET fill value: 10.
```

If the map projection of parameter data is specified to be lat/lon, the following

configuration should be used for specifying PET data. See Appendix B for more details about setting these values.

```
PET map projection: latlon
PET lower left lat: -59.87500
PET lower left lon: -179.87500
PET upper right lat: 89.87500
PET upper right lon: 179.87500
PET resolution (dx): 0.2500
PET resolution (dy): 0.2500
```

**CLSMF25 tile coord file:** specifies the location of a CLSM F2.5 coordinate file. This file contains catchment tile coordinate information that can be used in Catchment LSM (CLSM) Fortuna 2.5 version model run.

```
CLSMF25 tile coord file: ./cat_parms/PE_2880x1440_DE_464x224.file
```

**CLSMF25 soil param file:** specifies the location of a CLSM F2.5 soils file. This file contains catchment soil parameter information that can be used in Catchment LSM (CLSM) Fortuna 2.5 version model run.

```
CLSMF25 soil param file: ./cat_parms/soil_param.dat
```

**CLSMF25 topo files:** specifies the locations of a CLSM F2.5 topo parameter files. These files contain catchment topographic parameter information that can be used in a Catchment LSM (CLSM) Fortuna 2.5 version model run.

**CLSMF25 topo ar file:** specifies the table file containing topographic shape parameters for the CLSM F2.5 model. **CLSMF25 topo bf file:** specifies the table file containing topographic baseflow parameters for the CLSM F2.5 model. **CLSMF25 topo ts file:** specifies the table file containing water transfer timescale parameters for the CLSM F2.5 model.

```
CLSMF25 topo ar file: ../cat_parms/ar.new
CLSMF25 topo bf file: ../cat_parms/bf.dat
CLSMF25 topo ts file: ../cat_parms/ts.dat
```

**CLSMF25 surf layer ts file:** specifies the location of a CLSM F2.5 tau parameter file. This file contain catchment surface layer timescale (ts), tau, parameter information that can be used in Catchment LSM (CLSM) Fortuna 2.5 version model runs.

```
CLSMF25 surf layer ts file: .../cat_parms/tau_param.dat
```

**CLSMF25 top soil layer depth:** specifies the top soil layer depth. This parameter value specifies the depth of the top soil layer depth (unit: meters) and is needed in processing other parameters for a Catchment LSM (CLSM) Fortuna 2.5 version model run.

```
CLSMF25 top soil layer depth: 0.02
```

**CLSMF25 spatial transform:** indicates which spatial transform (i.e., upscale or downscale) type is to be applied to CLSM F2.5 parameters. Options include (only 'none' works at this time):

| Value | Description                               |
|-------|-------------------------------------------|
| none  | Data is on same grid as LIS output domain |

```
CLSMF25 spatial transform: none
```

This section also outlines the domain specifications of the Catchment LSM Fortuna 2.5 data. If the map projection of parameter data is specified to be lat/lon, the following configuration should be used for specifying CLSM data. See Appendix B for more details about setting these values.

```
CLSMF25 map projection: latlon
CLSMF25 lower left lat: 25.0625
CLSMF25 lower left lon: -124.9375
CLSMF25 upper right lat: 52.9375
CLSMF25 upper right lon: -67.0625
CLSMF25 resolution (dx): 0.125
CLSMF25 resolution (dy): 0.125
```

**RDHM356 constants table:** specifies the location of the constants table required by the Research Distributed Hydrologic Model (RDHM) version 3.5.6

models, SAC-HTET and SNOW-17. This table file contains constant values for any listed SAC-HTET or SNOW-17 parameter types. If a constant value is  $\zeta=0$ , then the constant value is assigned for all gridcells for a parameter entry. If the value is negative, a 2-D gridded a priori map is read in. Also, the negative constant value can be used as a scaling factor of the 2-D grid by taking its absolute value and multiplying the entire field by it, if the value is other than -1.

**RDHM356 universal undefined value:** specifies an universal undefined value that can be used by either the SAC-HTET or SNOW-17 models for run-time purposes.

|                                                         |
|---------------------------------------------------------|
| RDHM356 constants table: . ./rdhm_singlevalueinputs.txt |
| RDHM356 universal undefined value: -1.                  |

**Create or readin soil parameters:** specifies how the soil parameter files are either generated or brought in to the SAC-HTET model. Options include:

| Value  | Description                                                                                                                                         |
|--------|-----------------------------------------------------------------------------------------------------------------------------------------------------|
| none   | do not readin or create soil parameters                                                                                                             |
| readin | read in existing SAC soil parameter files                                                                                                           |
| create | generate SAC soil parameter fields in LDT<br>(currently only available at native STATSGOv1 grid<br>at the lat-lon grid and 0.00833 deg resolution.) |

|                                            |
|--------------------------------------------|
| Create or readin soil parameters: "readin" |
|--------------------------------------------|

**SACHTET soil parameter method:** specifies the method that can generate the SAC soil parameters. Options include (for now):

| Value    | Description                                                                               |
|----------|-------------------------------------------------------------------------------------------|
| none     | do not readin or create soil parameters                                                   |
| Koren_v1 | Based on Victor Koren (NOAA/OHD) original code developed to generate SAC soil parameters. |

|                                                             |
|-------------------------------------------------------------|
| SACHTET soil parameter method: "Koren_v1" # none   Koren_v1 |
|-------------------------------------------------------------|

**SACHTET Cosby soil parameter table:** specifies the path of the Cosby soil parameter table needed for the SAC-HTET soil parameters, especially for the generation of the parameters.

```
SACHTET Cosby soil parameter table: ./rdhm_parms/cosby_eq_newzperc.txt
```

**SACHTET parameter files:** specifies the locations of SACHTET 3.5.6 parameter files. These files contain soil-based and other model parameter information that can be used in SAC-HTET model runs. Most parameter files will come in the HRAP domain and XMRG-binary format found commonly in NOAA NWS/OHD/RFC applications. For the soil parameters, LZ indicates “lower zone” and UZ refers to “upper zone”.

**SACHTET soiltpe parameter table:** specifies the dominant soiltpe parameter table file.

**SACHTET vegetation parameter table:** specifies the vegetation parameter table file.

**SACHTET parameter spatial transform:** specifies generally the SAC-HTET grid spatial transform. Current option is “none”, and future options will be supported.

**SACHTET parameter fill option:** specifies generally the SAC-HTET parameter fill option. This option is not currently supported but can be in the future.

**SACHTET map projection:** specifies the general SAC-HTET parameter grid projection. Currently, “hrap” is supported and soon other projections, like “latlon” will be.

**SACHTET LZFPM map:** specifies the lower zone primary free water (slow) maximum storage [mm]

**SACHTET LZFSM map:** specifies the lower zone supplemental free water (fast) maximum storage [mm]

**SACHTET LZPK map:** specifies the lower zone primary free water depletion rate [day<sup>-1</sup>]

**SACHTET LZSK map:** specifies the lower zone supplemental free water depletion rate [day<sup>-1</sup>]

**SACHTET Lztwm map:** specifies the lower zone tension water maximum storage [mm]

**SACHTET Uzfwm map:** specifies the upper zone free water maximum storage [mm]

**SACHTET UZTWM map:** specifies the upper zone tension water maximum storage [mm]

**SACHTET UZK map:** specifies the upper zone free water latent depletion rate [day<sup>-1</sup>]

**SACHTET PFREE map:** specifies the fraction percolation from upper to lower free water storage [day<sup>-1</sup>]

**SACHTET REXP map:** specifies the exponent of the percolation equation (percolation parameter) [-]

**SACHTET ZPERC map:** specifies the maximum percolation rate [-]

**SACHTET EFC map:** specifies the fraction of forest cover [-]

**SACHTET PCTIM map:** specifies the impervious fraction of the watershed area [-]

**SACHTET ADIMP map:** specifies the additional impervious area [-]

**SACHTET SIDE map:** specifies the ratio of deep recharge to channel base flow [-]

**SACHTET RIVA map:** specifies the riparian vegetation area [-]

**SACHTET RSERV map:** specifies the fraction of lower zone free water not transferable to tension water [-]

**SACHTET TBOT map:** specifies the bottom boundary soil temperature [C]

**SACHTET STXT map:** specifies the SAC-HTET domain soil texture map file.

**SACHTET CKSL map:** specifies the ratio of frozen to non-frozen surface (increase in frozen ground contact, usually = 8 s/m) [s/m]

**SACHTET RSMAX map:** specifies the maximum residual porosity (usually = 0.58) [-]

**SACHTET ZBOT map:** specifies the lower boundary depth (negative value, usually = -2.5 m) [m]

|                                            |                                  |
|--------------------------------------------|----------------------------------|
| <b>SACHTET soiltype parameter table:</b>   | ./testcase/sachtet_soilparms.txt |
| <b>SACHTET vegetation parameter table:</b> | ./testcase/sachtet_vegparms.txt  |
| <b>SACHTET LZFPM map:</b>                  | ./testcase/sac_LZFPM.gz          |
| <b>SACHTET LZFSM map:</b>                  | ./testcase/sac_LZFSM.gz          |
| <b>SACHTET LZPK map:</b>                   | ./testcase/sac_LZPK.gz           |

|                                      |                                  |
|--------------------------------------|----------------------------------|
| SACHTET LZSK map:                    | ./testcase/sac_LZSK.gz           |
| SACHTET LZTWM map:                   | ./testcase/sac_LZTWM.gz          |
| SACHTET UZFWM map:                   | ./testcase/sac_UZFWM.gz          |
| SACHTET UZTWM map:                   | ./testcase/sac_UZTWM.gz          |
| SACHTET UZK map:                     | ./testcase/sac_UZK.gz            |
| SACHTET PFREE map:                   | ./testcase/sac_PFREE.gz          |
| SACHTET REXP map:                    | ./testcase/sac_REXP.gz           |
| SACHTET ZPERC map:                   | ./testcase/sac_ZPERC.gz          |
| SACHTET EFC map:                     | ./testcase/sac_EFC.gz            |
| SACHTET PCTIM map:                   | ./testcase/sac_PCTIM.gz          |
| SACHTET soil albedo map:             | ./testcase/sachtet_soilAlbedo.gz |
| SACHTET offset time map:             | ./testcase/sachtet_offsetTime.gz |
| SACHTET STXT map:                    | ./testcase/frz_STXT.gz           |
| SACHTET TBOT map:                    | ./testcase/frz_TBOT.gz           |
| SACHTET CKSL map:                    | none                             |
| SACHTET RSMAX map:                   | none                             |
| SACHTET ZBOT map:                    | none                             |
| SACHTET parameter spatial transform: | none                             |
| SACHTET parameter fill option:       | none                             |
| SACHTET map projection:              | hrap                             |

**SNOW17 parameter files:** specifies the locations of SNOW-17 parameter files. These files contain snow and soil-based parameter information that can be used in the SNOW-17 model run.

**SNOW17 ADC directory:** specifies the location of the multiband Snow-17 curve coordinates.

**SNOW17 ADC number of points:** specifies the number of areal depletion curve (ADC) points along the curve defining snow depletion rates.

**SNOW17 PGM map:** specifies the ground melt (in mm) input map.

**SNOW17 parameter spatial transform:** specifies the general grid spatial transform option for SNOW-17. Only current option for now is “none”.

**SNOW17 parameter fill option:** specifies the general SNOW-17 parameter fill option. This option is not currently supported but can be in the future.

**SNOW17 map projection:** specifies the general SNOW-17 parameter map projection. Currently only “hrap” is supported. Others like, “latlon”, will be supported in the future.

**SNOW17 MFMAX map:** specifies the maximum melt factor [mm/(6hrC)]

**SNOW17 MFMIN map:** specifies the minimum melt factor [mm/(6hrC)]

**SNOW17 UADJ map:** specifies the the average wind function during rain-on-snow periods [mm/mb]

**SNOW17 ALAT map:** specifies the latitude [-]

**SNOW17 ELEV map:** specifies the elevation [m]

**SNOW17 SCF map:** specifies the snow fall correction factor [-]

**SNOW17 NMF map:** specifies the maximum negative melt factor [mm/(6hrC)]

**SNOW17 SI map:** specifies the areal water-equivalent above which 100 percent areal snow cover [mm]

**SNOW17 MBASE map:** specifies the base temperature for non-rain melt factor [C]

**SNOW17 PXTEMP map:** specifies the temperature which spereates rain from snow [C]

**SNOW17 PLWHC map:** specifies the maximum amount of liquid-water held against gravity drainage [-]

**SNOW17 TIPM map:** specifies the antecedent snow temperature index parameter [-]

**SNOW17 LAEC map:** specifies the snow-rain split temperature [C]

|                              |                          |
|------------------------------|--------------------------|
| <b>SNOW17 MFMAX map:</b>     | ./testcase/snow_MFMAX.gz |
| <b>SNOW17 MFMIN map:</b>     | ./testcase/snow_MFMIN.gz |
| <b>SNOW17 UADJ map:</b>      | ./testcase/snow_UADJ.gz  |
| <b>SNOW17 ALAT map:</b>      | ./testcase/snow_ALAT.gz  |
| <b>SNOW17 ELEV map:</b>      | ./testcase/snow_ELEV.gz  |
| <b>SNOW17 SCF map:</b>       | none                     |
| <b>SNOW17 NMF map:</b>       | none                     |
| <b>SNOW17 SI map:</b>        | none                     |
| <b>SNOW17 MBASE map:</b>     | none                     |
| <b>SNOW17 PXTEMP map:</b>    | none                     |
| <b>SNOW17 PLWHC map:</b>     | none                     |
| <b>SNOW17 TIPM map:</b>      | none                     |
| <b>SNOW17 PGM map:</b>       | none                     |
| <b>SNOW17 ELEV map:</b>      | none                     |
| <b>SNOW17 LAEC map:</b>      | none                     |
| <b>SNOW17 ADC directory:</b> | none                     |

|                                     |      |
|-------------------------------------|------|
| SNOW17 ADC number of points:        | 11   |
| SNOW17 parameter spatial transform: | none |
| SNOW17 parameter fill option:       | none |
| SNOW17 map projection:              | hrap |

### 7.7.1 WRSI model parameter files

**WRSI landmask file:** specifies the location of the GeoWRSI 2.0 land mask file (default file is in \*BIL format). **WRSI length of growing period file:** specifies the location of the GeoWRSI 2.0 length of growing period file (default file is in \*BIL format). **WRSI water holding capacity file:** specifies the location of the GeoWRSI 2.0 water holding capacity file (default file is in \*BIL format). **WRSI WRSI climatology file:** specifies the location of the GeoWRSI 2.0 WRSI climatology file (default file is in \*BIL format). **WRSI SOS climatology file:** specifies the location of the GeoWRSI 2.0 SOS climatology file (default file is in \*BIL format). **WRSI SOS file:** specifies the location of an (optional) current start-of-season (SOS) file (default file is in \*BIL format). **WRSI SOS anomaly file:** specifies the location of an (optional) current (SOS) anomaly file (default file is in \*BIL format).

|                                     |                                    |
|-------------------------------------|------------------------------------|
| WRSI landmask file:                 | ./data/Africa/Static/sawmask       |
| WRSI length of growing period file: | ./data/Africa/Static/lgp_south     |
| WRSI water holding capacity file:   | ./data/Africa/Static/whc3          |
| WRSI WRSI climatology file:         | ./data/Africa/Static/wsimedn_edc_s |
| WRSI SOS climatology file:          | ./data/Africa/SOS/sosmedn_edc_s    |
| WRSI SOS file:                      | none                               |
| WRSI SOS anomaly file:              | none                               |

## 7.8 Climate Parameters

Climatology parameter maps

**PPT climatology data source:** specifies the monthly precipitation (PPT) climatology fields. Current source options include:

| Value     | Description                                                                                                                                    |
|-----------|------------------------------------------------------------------------------------------------------------------------------------------------|
| PRISM     | PRISM US-only climate downscaled fields. For more info, see: <a href="http://www.prism.oregonstate.edu/">http://www.prism.oregonstate.edu/</a> |
| WORLDCLIM | Global climate layers downscaled. For more info, see: <a href="http://www.worldclim.org/">http://www.worldclim.org/</a>                        |

**PPT climatology maps:** specifies the source of the climatology based precipitation files. The climatology precipitation data files can have the following naming conventions, depending on the data source:

PRISM: <directory>/<file header>.<tag>.txt

The file header can be anything (such as ppt\_1931\_2010).

The tag should represent the month (such as jan, feb, mar, etc.).

WORLDCLIM: <directory>/<file header>.<tag>.1gd4r

The file header can be prec\_

The tag should represent the month (such as 1, 2,..., 12).

**PPT climatology interval:** specifies the frequency of the precipitation climatology in months. Current option is: “monthly”.

```
PPT climatology data source: PRISM
PPT climatology maps: .../LS_PARAMETERS/climate_maps/ppt_1981_2010
PPT climatology interval: monthly
```

**Climate params spatial transform:** indicates which spatial transform (i.e., upscale or downscale) type is to be applied to climate parameters. Only “average” spatial transform works currently for the “WORLDCLIM” climatology files. Options include:

| Value           | Description                                          |
|-----------------|------------------------------------------------------|
| none            | Data is on same grid as LIS output domain            |
| average         | Upscale by averaging values for each gridcell        |
| neighbor        | Reinterpolate by selecting nearest gridcell neighbor |
| bilinear        | Reinterpolate by using bilinear interpolation        |
| budget-bilinear | Reinterpolate by using conservative, budget-bilinear |

```
Climate params spatial transform: average
```

This section also outlines the domain specifications of climatology-based parameters, like higher scaled monthly precipitation or min/max temperatures. If

the map projection of parameter data is specified to be lat/lon, the following configuration should be used for specifying climatology data. See Appendix B for more details about setting these values.

|                                |        |
|--------------------------------|--------|
| Climate params map projection: | latlon |
|--------------------------------|--------|

## 7.9 Forcing Parameters

### 7.9.1 NLDAS-2 Forcing based parameter inputs

**NLDAS2 elevation difference map:** specifies the NLDAS-2 elevation difference file used to remove built-in elevation correction.

**NARR terrain height map:** specifies the terrain height map for the NLDAS-2 base forcing of the North American Regional Reanalysis (NARR).

If the run mode option selected is “Metforce processing” or “Metforce temporal downscaling”, please see the latest LIS Users’ Guide.

|                                  |                          |
|----------------------------------|--------------------------|
| NLDAS2 elevation difference map: | .../NARR_elev-diff.1gd4r |
| NARR terrain height map:         | .../NARR_elevation.1gd4r |

### 7.9.2 NLDAS-1 Forcing based parameter inputs

**NLDAS1 elevation difference map:** specifies the NLDAS-1 elevation difference file used to remove built-in elevation correction.

**EDAS terrain height map:** specifies the terrain height map for the NLDAS-1 base forcing of the Eta Data Assimilation System (EDAS).

If the run mode option selected is “Metforce processing” or “Metforce temporal downscaling”, please see the latest LIS Users’ Guide.

|                                  |                                 |
|----------------------------------|---------------------------------|
| NLDAS1 elevation difference map: | .../NLDAS1/EDAS_elev-diff.1gd4r |
| EDAS terrain height map:         | .../NLDAS1/EDAS_elevation.1gd4r |

### **7.9.3 PRINCETON Forcing based parameter inputs**

**PRINCETON elevation map:** specifies the terrain height map for the Princeton University global forcing dataset.

If the run mode option selected is “Metforce processing” or “Metforce temporal downscaling”, please see the latest LIS Users’ Guide.

```
PRINCETON elevation map: ./PRINCETON/hydro1k_elev_mean_1d.asc
```

### **7.9.4 NAM242 Forcing based parameter inputs**

**NAM242 elevation map:** specifies the terrain height map for the North American Mesoscale (NAM) NOAA grid 242 forcing dataset.

If the run mode option selected is “Metforce processing” or “Metforce temporal downscaling”, please see the latest LIS Users’ Guide.

```
NAM242 elevation map: ./NAM/terrain.242.grb
```

### **7.9.5 GDAS**

**GDAS parameter inputs:** GDAS elevation maps specify lowest boundary layer information which can be used to downscale or lapse rate adjust GDAS meteorological variables, if given a higher resolution elevation height map. Original files are given in Grib-1 format and on their original Gaussian grids (from NCEP), so the GDAS elevation file reader is set up to support these files.

**GDAS T126 elevation map:** specifies the GDAS T126 elevation definition.

**GDAS T170 elevation map:** specifies the GDAS T170 elevation definition.

**GDAS T254 elevation map:** specifies the GDAS T254 elevation definition.

**GDAS T382 elevation map:** specifies the GDAS T382 elevation definition.

**GDAS T574 elevation map:** specifies the GDAS T574 elevation definition.

**GDAS T1534 elevation map:** specifies the GDAS T1534 elevation definition.

If the run mode option selected is “Metforce processing” or “Metforce temporal downscaling”, please see the latest LIS Users’ Guide.

```
GDAS T126 elevation map: ./GDAS/global_orography.t126.grb
GDAS T170 elevation map: ./GDAS/global_orography.t170.grb
GDAS T254 elevation map: ./GDAS/global_orography.t254.grb
GDAS T382 elevation map: ./GDAS/global_orography.t382.grb
GDAS T574 elevation map: ./GDAS/global_orography.t574.grb
GDAS T1534 elevation map: ./GDAS/global_orography_uf.t1534.3072.1536.grb
```

### 7.9.6 ECMWF

ECMWF parameter inputs: ECMWF elevation maps specify lowest boundary layer information which can be used to downscale or lapse rate adjust ECMWF meteorological variables, if given a higher resolution elevation height map. Original files are given in Grib-1 format and on their original lat-lon grids (from ECMWF), so the ECMWF elevation file reader is set up to support these files.

**ECMWF IFS23R4 elevation map:** specifies the ECMWF IFS23R4 terrain height map file path.

**ECMWF IFS25R1 elevation map:** specifies the ECMWF IFS25R1 terrain height map file path.

**ECMWF IFS30R1 elevation map:** specifies the ECMWF IFS30R1 terrain height map file path.

**ECMWF IFS33R1 elevation map:** specifies the ECMWF IFS33R1 terrain height map file path.

**ECMWF IFS35R2 elevation map:** specifies the ECMWF IFS35R2 terrain height map file path.

**ECMWF IFS35R3 elevation map:** specifies the ECMWF IFS35R3 terrain height map file path.

**ECMWF IFS36R1 elevation map:** specifies the ECMWF IFS36R1 terrain height map file path.

**ECMWF IFS37R2 elevation map:** specifies the ECMWF IFS37R2 terrain height map file path.

If the run mode option selected is “Metforce processing” or “Metforce temporal

downscaling”, please see the latest LIS Users’ Guide.

```
ECMWF IFS23R4 elevation map: ./ECMWF/ecmwf.2001092006.092006.elev_1_4
ECMWF IFS25R1 elevation map: ./ECMWF/ecmwf.2003010806.010806.elev_1_4
ECMWF IFS30R1 elevation map: ./ECMWF/ecmwf.2006020106.020106.elev_1_4
ECMWF IFS33R1 elevation map: ./ECMWF/ecmwf.2008060306.060306.elev_1_4
ECMWF IFS35R2 elevation map: ./ECMWF/ecmwf.2009031006.031006.elev_1_4
ECMWF IFS35R3 elevation map: ./ECMWF/ecmwf.2009090806.090806.elev_1_4
ECMWF IFS36R1 elevation map: ./ECMWF/ecmwf.2010012606.012606.elev_1_4
ECMWF IFS37R2 elevation map: ./ECMWF/ecmwf.2011051806.051806.elev_1_4
```

#### 7.9.7 ECMWF Reanalysis Forcing based parameter inputs

ECMWF Reanalysis elevation map: specifies the ECMWF Reanalysis elevation file.

ECMWF Reanalysis elevation spatial transform: specifies the terrain height map spatial grid transform option (e.g., average).

If the run mode option selected is “Metforce processing” or “Metforce temporal downscaling”, please see the latest LIS Users’ Guide.

```
ECMWF Reanalysis elevation map: ./metforcing_parms/ECMWFRean/elev_ECMWF-reanalysis.1gd4r
ECMWF Reanalysis elevation spatial transform: "average"
```

#### 7.9.8 TRMM 3B42RTV7 precipitation

If the run mode option selected is “Metforce processing” or “Metforce temporal downscaling”, please see the latest LIS Users’ Guide.

#### 7.9.9 TRMM 3B42V6 precipitation

If the run mode option selected is “Metforce processing” or “Metforce temporal downscaling”, please see the latest LIS Users’ Guide.

### **7.9.10 TRMM 3B42V7 precipitation**

If the run mode option selected is “Metforce processing” or “Metforce temporal downscaling”, please see the latest LIS Users’ Guide.

### **7.9.11 CMAP precipitation**

If the run mode option selected is “Metforce processing” or “Metforce temporal downscaling”, please see the latest LIS Users’ Guide.

### **7.9.12 CMORPH precipitation**

If the run mode option selected is “Metforce processing” or “Metforce temporal downscaling”, please see the latest LIS Users’ Guide.

### **7.9.13 MERRA-Land forcing**

If the run mode option selected is “Metforce processing” or “Metforce temporal downscaling”, please see the latest LIS Users’ Guide.

### **7.9.14 RDHM356 forcing**

If the run mode option selected is “Metforce processing” or “Metforce temporal downscaling”, please see the latest LIS Users’ Guide.

### **7.9.15 RFE2Daily precipitation**

If the run mode option selected is “Metforce processing” or “Metforce temporal downscaling”, please see the latest LIS Users’ Guide.

### **7.9.16 CHIRPSv2 precipitation**

If the run mode option selected is “Metforce processing” or “Metforce temporal downscaling”, please see the latest LIS Users’ Guide.

### **7.9.17 Stage II precipitation**

If the run mode option selected is “Metforce processing” or “Metforce temporal downscaling”, please see the latest LIS Users’ Guide.

### **7.9.18 Stage IV precipitation**

If the run mode option selected is “Metforce processing” or “Metforce temporal downscaling”, please see the latest LIS Users’ Guide.

## **7.10 Ensemble restart model options**

**LIS restart source:** specifies the surface model restart file source. Options are:

| Value   | Description                                         |
|---------|-----------------------------------------------------|
| LSM     | LSM restart file type                               |
| Routing | river or streamflow routing model restart file type |

```
LIS restart source: "LSM"
```

**Ensemble restart generation mode:** specifies the mode of ensemble restart generation. Options are:

| Value     | Description                                                    |
|-----------|----------------------------------------------------------------|
| upscale   | convert from a single member restart to a multi-member restart |
| downscale | convert from a multi-member restart to a single member restart |

```
Ensemble restart generation mode: "upscale"
```

**Input restart filename:** specifies the name of the input restart file.

```
Input restart filename: ../OL/LIS_RST_NOAH33_201001010000.d01.nc
```

**Output restart filename:** specifies the name of the output restart file.

```
Output restart filename: ./LIS_RST_NOAH33_201001010000.d01.nc
```

**Number of ensembles per tile (input restart):** specifies the number of ensemble members used in the input restart file.

```
Number of ensembles per tile (input restart): 1
```

**Number of ensembles per tile (output restart):** specifies the number of ensemble members to be used in the output restart file.

```
Number of ensembles per tile (output restart): 12
```

**Note:** Make sure to specify the surface type, veg, soil, etc., subgrid tiling entries For upscaling or downscaling of restart files, maximum number of tiles and minimum cutoff percentage entries for subgrid tiling based on vegetation or other parameter types (e.g., soil type, elevation, etc.) are required as entries.

For example, must include, Maximum number of surface type tiles per grid:

## 7.11 NUWRF preprocessing for real options

The section describes some of the LDT-based NUWRF real input processing options.

**LIS history file for land state initialization:** specifies the file name of the LIS history file to use to initialize the land state.

**Processed NUWRF file for input to real:** specifies the file name of the generated file that is then used as input to the real.exe program in NUWRF.

```
LIS history file for land state initialization: EXAMPLE
Processed NUWRF file for input to real: EXAMPLE
```

## 7.12 Data Assimilation preprocessing options

The start time is specified in the following format:

| Variable         | Value                  | Description                |
|------------------|------------------------|----------------------------|
| Starting year:   | integer 2001 – present | specifying starting year   |
| Starting month:  | integer 1 – 12         | specifying starting month  |
| Starting day:    | integer 1 – 31         | specifying starting day    |
| Starting hour:   | integer 0 – 23         | specifying starting hour   |
| Starting minute: | integer 0 – 59         | specifying starting minute |
| Starting second: | integer 0 – 59         | specifying starting second |

|                  |      |
|------------------|------|
| Starting year:   | 2002 |
| Starting month:  | 1    |
| Starting day:    | 2    |
| Starting hour:   | 0    |
| Starting minute: | 0    |
| Starting second: | 0    |

The end time is specified in the following format:

| Variable       | Value                  | Description              |
|----------------|------------------------|--------------------------|
| Ending year:   | integer 2001 – present | specifying ending year   |
| Ending month:  | integer 1 – 12         | specifying ending month  |
| Ending day:    | integer 1 – 31         | specifying ending day    |
| Ending hour:   | integer 0 – 23         | specifying ending hour   |
| Ending minute: | integer 0 – 59         | specifying ending minute |
| Ending second: | integer 0 – 59         | specifying ending second |

|                |      |
|----------------|------|
| Ending year:   | 2010 |
| Ending month:  | 1    |
| Ending day:    | 1    |
| Ending hour:   | 0    |
| Ending minute: | 0    |
| Ending second: | 0    |

LIS output timestep: specifies the LIS output time-step.

|                      |     |
|----------------------|-----|
| LIS output timestep: | 1da |
|----------------------|-----|

**DA observation source:** specifies the source of the observation data on which preprocessing is performed. Options are:

| Value                      | Description                                                                                  |
|----------------------------|----------------------------------------------------------------------------------------------|
| LIS LSM soil moisture      | soil moisture output from a LIS run                                                          |
| Synthetic soil moisture    | synethtic soil moisture observations created from a LIS run                                  |
| AMSR-E(LPRM) soil moisture | Land Parameter Retrieval Model (LPRM) retrievals of AMSR-E soil moisture                     |
| AMSR-E(NASA) soil moisture | NASA AMSR-E soil moisture                                                                    |
| ECV soil moisture          | Essential Climate Variable (ECV) soil moisture retrievals                                    |
| WindSat soil moisture      | WindSat retrievals of soil moisture                                                          |
| RT SMOPS soil moisture     | Real Time Soil Moisture Operational Processing System (SMOPS) based soil moisture retrievals |
| ASCAT TUW soil moisture    | ASCAT soil moisture retrievals from TU Wein                                                  |
| GRACE TWS                  | Terrestrial water storage observations from GRACE                                            |
| Simulated GRACE            | Simulated water storage observations from GRACE                                              |

```
DA observation source: "AMSR-E(LPRM) soil moisture"
```

**Apply anomaly correction to obs:** specifies if observations are to be created by applying an anomaly correction. This option is only used for GRACE TWS observations.

```
Apply anomaly correction to obs: 0
```

**Compute CDF:** specifies if cumulative distribution function (CDF) is to be computed

```
Compute CDF: 1
```

**Number of bins to use in the CDF:** specifies the number of bins to use while computing the CDF.

```
Number of bins to use in the CDF: 100
```

**Name of CDF file:** specifies name of the CDF file being generated. (This will be a NETCDF formatted file.)

|                              |
|------------------------------|
| Name of CDF file: "lprm_cdf" |
|------------------------------|

**Temporal resolution of CDFs:** specifies whether to generate lumped (considering all years and all seasons) CDFs or to stratify CDFs for each calendar month. Acceptable values are:

| Value   | Description                                  |
|---------|----------------------------------------------|
| monthly | stratify for each calendar month             |
| yearly  | lump (considering all years and all seasons) |

|                                      |
|--------------------------------------|
| Temporal resolution of CDFs: monthly |
|--------------------------------------|

**Group CDFs by external data:** specifies whether to group CDFs for each pixel by an externally specified categorical map; for example, by landcover. Acceptable values are:

| Value | Description                   |
|-------|-------------------------------|
| 0     | do not group by external data |
| 1     | group by external data        |

|                                |
|--------------------------------|
| Group CDFs by external data: 0 |
|--------------------------------|

**CDF grouping attributes file:** specifies the name of an ASCII file that specifies the attributes of the CDF grouping, if enabled. A sample file is shown below. The first line is a description. The second line is the name of the file containing the external data for grouping. The third line is a description. The fourth line is the minimum value of the categorical data, followed by the maximum value of the categorical data, followed by the number of bins of the categorical data.

```
#category file
landcover.1gd4r
#min max nbins
1 19 18
```

```
CDF grouping attributes file: cdf_grouping.txt
```

**Temporal averaging interval:** specifies temporal averaging interval to be used while computing the CDF.

```
Temporal averaging interval: "1da"
```

**Apply external mask:** specifies if an external mask (time varying) is to be applied while computing the CDF.

```
Apply external mask: 0
```

**External mask directory:** specifies the location of the external mask.

```
External mask directory: none
```

**Observation count threshold:** specifies the minimum number of observations to be used for generating valid CDF data.

```
Observation count threshold: 500
```

**LIS soil moisture output format:** specifies the output format of the LIS model output. (binary/netcdf/grib1)

**LIS soil moisture output methodology:** specifies the output methodology used in the LIS model output (1d tilespace/1d gridspace/2d gridspace).

**LIS soil moisture output naming style:** specifies the output naming style used in the LIS model output (3 level hierarchy/4 level hierarchy, etc.).

**LIS soil moisture output nest index:** specifies the index of the nest used in the LIS model output.

**LIS soil moisture output directory:** specifies the location of the LIS model output.

**LIS soil moisture output timestep:** specifies the output timestep of the LIS soil moisture.

**LIS soil moisture output map projection:** specifies the map projection used in the LIS model output.

**LIS soil moisture domain lower left lat:** specifies the lower left latitude of the LIS model output (if map projection is latlon).

**LIS soil moisture domain lower left lon:** specifies the lower left longitude of the LIS model output (if map projection is latlon).

**LIS soil moisture domain upper right lat:** specifies the upper right latitude of the LIS model output (if map projection is latlon).

**LIS soil moisture domain upper right lon:** specifies the upper right longitude of the LIS model output (if map projection is latlon).

**LIS soil moisture domain resolution (dx):** specifies the resolution (in degrees) along the latitude of the LIS model output (if map projection is latlon).

**LIS soil moisture domain resolution (dy):** specifies the resolution (in degrees) along the longitude of the LIS model output (if map projection is latlon).

**LIS soil moisture security class:** specifies the security classification for the LIS model output file, used only for WMO-convention output.

**LIS soil moisture distribution class:** specifies the distribution classification for the LIS model output file, used only for WMO-convention output.

**LIS soil moisture data category:** specifies the data category for the LIS model output file, used only for WMO-convention output.

**LIS soil moisture area of data:** specifies the area of data for the LIS model output file, used only for WMO-convention output.

**LIS soil moisture write interval:** specifies the write interval for the LIS model output file, used only for WMO-convention output.

|                                          |                     |
|------------------------------------------|---------------------|
| LIS soil moisture output format:         | "netcdf"            |
| LIS soil moisture output methodology:    | "2d gridspace"      |
| LIS soil moisture output naming style:   | "3 level hierarchy" |
| LIS soil moisture output map projection: | "latlon"            |
| LIS soil moisture output nest index:     | 1                   |
| LIS soil moisture output timestep:       | EXAMPLE             |

```
LIS soil moisture output directory: ./OL/OUTPUT
LIS soil moisture domain lower left lat: 18.375
LIS soil moisture domain lower left lon: -111.375
LIS soil moisture domain upper right lat: 41.375
LIS soil moisture domain upper right lon: -85.875
LIS soil moisture domain resolution (dx): 0.25
LIS soil moisture domain resolution (dy): 0.25
LIS soil moisture security class:
LIS soil moisture distribution class:
LIS soil moisture data category:
LIS soil moisture area of data:
LIS soil moisture write interval:
```

**Synthetic soil moisture observation directory:** specifies the location of the data directory containing the synthetic soil moisture data.

**Synthetic soil moisture observation timestep:** specifies the timestep of the synthetic soil moisture observations.

```
Synthetic soil moisture observation directory: ./SYN_SM
Synthetic soil moisture observation timestep: EXAMPLE
```

**AMSR-E(LPRM) soil moisture observation directory:** specifies the location of the data directory containing the LPRM AMSR-E data.

**AMSR-E(LPRM) use raw data:** specifies if raw data (instead of the retrievals CDF-matched to the GLDAS Noah climatology).

```
AMSR-E(LPRM) soil moisture observation directory: ./LPRM.v5
AMSR-E(LPRM) use raw data: 1
```

**NASA AMSRE soil moisture observation directory:** specifies the location of the data directory containing the NASA AMSR-E data.

```
NASA AMSRE soil moisture observation directory: ./NASA_AMSRE
```

**ECV soil moisture observation directory:** specifies the location of the data directory containing the ECV soil moisture data.

**ECV soil moisture version of data:** specifies the version of the ECV soil moisture dataset.

|                                          |         |
|------------------------------------------|---------|
| ECV soil moisture observation directory: | ./ECV   |
| ECV soil moisture version of data:       | EXAMPLE |

**GCOMW AMSR2 L3 soil moisture observation directory:** specifies the location of the data directory containing the GCOMW AMSR v2 L3 soil moisture data.

|                                                     |               |
|-----------------------------------------------------|---------------|
| GCOMW AMSR2 L3 soil moisture observation directory: | ./GCOMW_AMSR2 |
|-----------------------------------------------------|---------------|

**WindSat soil moisture observation directory:** specifies the location of the data directory containing the WindSat soil moisture data.

|                                              |           |
|----------------------------------------------|-----------|
| WindSat soil moisture observation directory: | ./WindSat |
|----------------------------------------------|-----------|

**Aquarius L2 soil moisture observation directory:** specifies the location of the data directory containing the Aquarius soil moisture data.

|                                                  |                |
|--------------------------------------------------|----------------|
| Aquarius L2 soil moisture observation directory: | ./Aquarius_SM/ |
|--------------------------------------------------|----------------|

**SMOS L2 soil moisture observation directory:** specifies the location of the data directory containing the SMOS soil moisture data.

|                                              |            |
|----------------------------------------------|------------|
| SMOS L2 soil moisture observation directory: | ./SMOS_SM/ |
|----------------------------------------------|------------|

**RT SMOPS soil moisture observation directory:** specifies the location of the data directory containing the real time SMOPS soil moisture data.

**RT SMOPS soil moisture use ASCAT data:** specifies if the ASCAT layer of SMOPS is to be used.

**RT SMOPS soil moisture use WindSat data:** specifies if the WindSat layer of SMOPS is to be used.

**RT SMOPS soil moisture use SMOS data:** specifies if the SMOS layer of SMOPS is to be used.

```
RT SMOPS soil moisture observation directory: ./RTSMOPS
RT SMOPS soil moisture use ASCAT data: 1
RT SMOPS soil moisture use WindSat data: 0
RT SMOPS soil moisture use SMOS data: 0
```

**ASCAT (TUW) soil moisture observation directory:** specifies the location of the data directory containing the TU Wein retrievals of ASCAT soil moisture data.

```
ASCAT (TUW) soil moisture observation directory: ./TUW_ASCAT
```

**GRACE raw data filename:** specifies the name of the GRACE raw data.

**GRACE baseline starting year:** specifies the baseline starting year from which to establish the TWS climatology.

**GRACE baseline ending year:** specifies the baseline ending year from which to establish the TWS climatology.

**GRACE scale factor filename:** specifies the name of the file containing the GRACE scale factor. This is NetCDF file provided by JPL.

**GRACE measurement error filename:** specifies the name of the file containing the GRACE measurement error. This is a NetCDF file provided by JPL.

**GRACE process basin averaged observations:** specifies whether to process basin averaged observations. Default value is 0. Acceptable values are:

| Value | Description    |
|-------|----------------|
| 0     | do not process |
| 1     | process        |

**GRACE basin map file:** specifies the file name of the basin map data.

**LIS TWS output format:** specifies the output format of the LIS model output (binary/netcdf/grib1).

**LIS TWS output methodology:** specifies the output methodology used in the LIS model output (1d tilespace/1d gridspace/2d gridspace).

**LIS TWS output naming style:** specifies the output naming style used in the LIS model output (3 level hierarchy/4 level hierarchy, etc.).

**LIS TWS output nest index:** specifies the index of the nest used in the LIS model output.

**LIS TWS output directory:** specifies the location of the LIS model output.

**LIS TWS output map projection:** specifies the map projection used in the LIS model output.

**LIS TWS output domain lower left lat:** specifies the lower left latitude of the LIS model output (if map projection is latlon).

**LIS TWS output domain lower left lon:** specifies the lower left longitude of the LIS model output (if map projection is latlon).

**LIS TWS output domain upper right lat:** specifies the upper right latitude of the LIS model output (if map projection is latlon).

**LIS TWS output domain upper right lon:** specifies the upper right longitude of the LIS model output (if map projection is latlon).

**LIS TWS output domain resolution (dx):** specifies the resolution (in degrees) along the latitude of the LIS model output (if map projection is latlon).

**LIS TWS output domain resolution (dy):** specifies the resolution (in degrees) along the longitude of the LIS model output (if map projection is latlon).

```
GRACE raw data filename: ./GRACE_tws/GRACE.CSR.LAND.RL05.DS.G200KM.nc
GRACE baseline starting year: 2004
GRACE baseline ending year: 2009
GRACE scale factor filename: EXAMPLE
GRACE measurement error filename: EXAMPLE
LIS TWS output format: "netcdf"
LIS TWS output methodology: "2d gridspace"
LIS TWS output naming style: "3 level hierarchy"
LIS TWS output map projection: "latlon"
LIS TWS output nest index: 1
LIS TWS output directory: ./OL_NLDAS/OUTPUT
LIS TWS output domain lower left lat: 25.0625
LIS TWS output domain lower left lon: -124.9375
LIS TWS output domain upper right lat: 52.9375
LIS TWS output domain upper right lon: -67.0625
LIS TWS output domain resolution (dx): 0.125
```

|                                        |       |
|----------------------------------------|-------|
| LIS TWS output domain resolution (dy): | 0.125 |
|----------------------------------------|-------|

**Simulated GRACE data directory:** specifies the directory containing the simulated GRACE observations.

**Simulated GRACE configuration:** specifies the simulated GRACE configuration. Acceptable values are:

| Value       | Description |
|-------------|-------------|
| “default”   | default     |
| “follow-on” | follow on   |
| “GRACE-2”   | GRACE-2     |

**Simulated GRACE baseline starting year:** specifies the baseline starting year from which to establish the simulated TWS climatology.

**Simulated GRACE baseline ending year:** specifies the baseline ending year from which to establish the simulated TWS climatology.

**LIS TWS output format:** specifies the output format of the LIS model output (binary/netcdf/grib1).

**LIS TWS output methodology:** specifies the output methodology used in the LIS model output (1d tilespace/1d gridspace/2d gridspace).

**LIS TWS output naming style:** specifies the output naming style used in the LIS model output (3 level hierarchy/4 level hierarchy, etc.).

**LIS TWS output nest index:** specifies the index of the nest used in the LIS model output.

**LIS TWS output directory:** specifies the location of the LIS model output.

**LIS TWS output map projection:** specifies the map projection used in the LIS model output.

**LIS TWS output domain lower left lat:** specifies the lower left latitude of the LIS model output (if map projection is latlon).

**LIS TWS output domain lower left lon:** specifies the lower left longitude of the LIS model output (if map projection is latlon).

**LIS TWS output domain upper right lat:** specifies the upper right latitude of the LIS model output (if map projection is latlon).

**LIS TWS output domain upper right lon:** specifies the upper right longitude of the LIS model output (if map projection is latlon).

**LIS TWS output domain resolution (dx):** specifies the resolution (in degrees) along the latitude of the LIS model output (if map projection is latlon).

**LIS TWS output domain resolution (dy):** specifies the resolution (in degrees) along the longitude of the LIS model output (if map projection is latlon).

|                                         |                     |
|-----------------------------------------|---------------------|
| Simulated GRACE data directory:         | sim_grace           |
| Simulated GRACE configuration:          | default             |
| Simulated GRACE baseline starting year: | 2004                |
| Simulated GRACE baseline ending year:   | 2009                |
| LIS TWS output format:                  | "netcdf"            |
| LIS TWS output methodology:             | "2d gridspace"      |
| LIS TWS output naming style:            | "3 level hierarchy" |
| LIS TWS output map projection:          | "latlon"            |
| LIS TWS output nest index:              | 1                   |
| LIS TWS output directory:               | ../OL_NLDAS/OUTPUT  |
| LIS TWS output domain lower left lat:   | 25.0625             |
| LIS TWS output domain lower left lon:   | -124.9375           |
| LIS TWS output domain upper right lat:  | 52.9375             |
| LIS TWS output domain upper right lon:  | -67.0625            |
| LIS TWS output domain resolution (dx):  | 0.125               |
| LIS TWS output domain resolution (dy):  | 0.125               |

**HYMAP river width map:** specifies the name of the HYMAP river width data file.

**HYMAP river height map:** specifies the name of the HYMAP river height data file.

**HYMAP river roughness map:** specifies the name of the HYMAP river roughness data file.

**HYMAP floodplain height map:** specifies the name of the HYMAP floodplain height data file.

**HYMAP floodplain height levels:** specifies the number of the HYMAP floodplain height levels.

**HYMAP flow direction x map:** specifies the name of the x-flow direction data file.

**HYMAP flow direction y map:** specifies the name of the y-flow direction data file.

**HYMAP grid elevation map:** specifies the name of the grid elevation data file.

**HYMAP grid distance map:** specifies the name of the grid distance data file.

**HYMAP grid area map:** specifies the name of the grid area data file.

**HYMAP runoff time delay map:** specifies the name of the runoff time delay data file.

**HYMAP runoff time delay multiplier map:** specifies the name of the runoff time delay multiplier data file.

**HYMAP baseflow time delay map:** specifies the name of the baseflow time delay data file .

**HYMAP reference discharge map:** specifies the name of the reference discharge data file.

**HYMAP basin mask map:** specifies the name of the basin mask data file.

**HYMAP river length map:** specifies the name of the river length data file.

**HYMAP floodplain roughness map:** specifies the name of floodplain roughness map file.

|                                                |                                           |
|------------------------------------------------|-------------------------------------------|
| <b>HYMAP river width map:</b>                  | .../HYMAP_parms/rivwth_Getirana_Dutra.bin |
| <b>HYMAP river height map:</b>                 | .../HYMAP_parms/rivhgt_Getirana_Dutra.bin |
| <b>HYMAP river roughness map:</b>              | .../HYMAP_parms/rivman_Getirana_Dutra.bin |
| <b>HYMAP floodplain roughness map:</b>         | .../HYMAP_parms/fldman.bin                |
| <b>HYMAP river length map:</b>                 | .../HYMAP_parms/rivlen.bin                |
| <b>HYMAP floodplain height map:</b>            | .../HYMAP_parms/fldhgt.bin                |
| <b>HYMAP floodplain height levels:</b>         | 10                                        |
| <b>HYMAP flow direction x map:</b>             | .../HYMAP_parms/nextx.bin                 |
| <b>HYMAP flow direction y map:</b>             | .../HYMAP_parms/nexty.bin                 |
| <b>HYMAP grid elevation map:</b>               | .../HYMAP_parms/elevtn.bin                |
| <b>HYMAP grid distance map:</b>                | .../HYMAP_parms/nxtdst.bin                |
| <b>HYMAP grid area map:</b>                    | .../HYMAP_parms/grarea.bin                |
| <b>HYMAP runoff time delay map:</b>            | .../HYMAP_parms/kirpitch.bin              |
| <b>HYMAP runoff time delay multiplier map:</b> | .../HYMAP_parms/trunoff.bin               |
| <b>HYMAP baseflow time delay map:</b>          | .../HYMAP_parms/tbasflw_45_amazon.bin     |
| <b>HYMAP reference discharge map:</b>          | .../HYMAP_parms/qrefer.bin                |

```
HYMAP basin mask map:
```

```
.../HYMAP_parms/mask_all.bin
```

This section also outlines the domain specifications of the HYMAP parameter data. For the HYMAP parameters spatial transform option, only 'none' is supported at this time, and the user is required to input the HYMAP parameters at the grid and resolution of interest.

If the map projection of parameter data is specified to be lat/lon, the following configuration should be used for specifying HYMAP data See Appendix B for more details about setting these values.

|                                 |           |
|---------------------------------|-----------|
| HYMAP params spatial transform: | none      |
| HYMAP params map projection:    | latlon    |
| HYMAP params lower left lat:    | -59.9375  |
| HYMAP params lower left lon:    | -179.9375 |
| HYMAP params upper right lat:   | 89.9375   |
| HYMAP params upper right lon:   | 179.9375  |
| HYMAP params resolution (dx):   | 0.125     |
| HYMAP params resolution (dy):   | 0.125     |

## A Description of output files from LDT

This section provides a description of various output files generated during an LDT processing run. The main output format for LDT is NetCDF (\*.nc). This includes NetCDF with HDF5 compression capabilities.

The output file could be named something like, lis\_input.d01.nc. To view the header and/or data information, you will need ncview and/or ncdump utilities, both provided by the Unidata webpage var(<http://www.unidata.ucar.edu/software/netcdf/>).

Some of the main components (as found in the header information) will include:

- dimensions : *east\_west, north\_south, month, sfctypes, etc.*
- variables : *time, LANDMASK, LANDCOVER, SURFACETYPE, etc.*
- global attributes : *title, references, MAP\_PROJECTION, DX, DY, etc.*

### A.0.1 Dimensions attributes

The LDT output file, like the NetCDF file, contains header information for the dimensions. The list can include:

```
dimensions:
 east_west = 80 ;
 north_south = 37 ;
 month = 12 ;
 time = 1 ;
 sfctypes = 14 ;
 soiltypes = 16 ;
 soilfracbins = 3 ;
 elevbins = 1 ;
 slopebins = 1 ;
 aspectbins = 1 ;
....
....
```

This file can be used to determine the number of tiles used in a LIS model simulation. The number of tiles are specified in this dimensions header information.

### A.0.2 Variable attributes

The LDT output file, like the NetCDF file, contains header information for the variable or parameter file attributes. The list can include: (for example)

```
variables:
 float LANDCOVER(sfctypes, north_south, east_west) ;
 LANDCOVER:standard_name = "UMD land cover" ;
 LANDCOVER:units = "-" ;
 LANDCOVER:scale_factor = 1.f ;
 LANDCOVER:add_offset = 0.f ;
 LANDCOVER:missing_value = -9999.f ;
 LANDCOVER:vmin = 0.f ;
 LANDCOVER:vmax = 0.f ;
 LANDCOVER:num_bins = 14 ;


```

## B Cylindrical Lat/Lon Domain Example

This section describes how to compute the values for the run domain and/or the domain for a parameter or variable file on a cylindrical lat/lon projection.

First, the ‘LIS-produced’ parameter data are defined on a Latitude/Longitude grid, from  $-180$  to  $180$  degrees longitude and from  $-60$  to  $90$  degrees latitude. Whereas most ‘Native’ parameter datasets can extend down to  $-90$  degrees latitude, accounting for glacial areas like Antarctica.

LDT is designed to bring a read-in parameter file directly to a common LIS-based domain grid, projection and resolution. Currently, the user can upscale or downscale from a given lat/lon projection to any other lat/lon projection but also lambert conformal and other projections.

For this example, consider reading in an older ‘LIS-produced’ parameter file at  $1/4$  deg resolution. The coordinates of the south-west and the north-east points must be specified at the grid-cells’ centers. Here the south-west grid-cell is given by the box  $(-180, -60), (-179.750, -59.750)$ . The center of this box is  $(-179.875, -59.875)$ .<sup>1</sup> Thus the `lower left lat:` is  $-59.875$ , and the `lower left lon:` is  $-179.875$ .

The north-east grid-cell is given by the box  $(179.750, 89.750), (180, 90)$ . Its center is  $(179.875, 89.875)$ . Thus the `upper right lat:` is  $89.875$ , and the `upper right lon:` is  $179.875$ .

Setting the resolution ( $0.25$  deg) gives `domain resolution dx:` is  $0.25$  and `domain resolution dy:` is  $0.25$ .

Now let’s consider setting the bounding coordinates for your desired LIS-based run domain.

If you wish to run over the whole domain defined by a parameter data domain then you simply set the values defined in the parameter domain section in the run domain section. For this example, this gives:

```
Run domain lower left lat: -59.875
Run domain lower left lon: -179.875
Run domain upper right lat: 89.875
Run domain upper right lon: 179.875
Run domain resolution dx: 0.25
Run domain resolution dy: 0.25
```

---

<sup>1</sup>Note, these coordinates are ordered (longitude, latitude).

Just note that if you wish to run on a LIS run domain that happens to be greater (e.g. all of North America) than the extents of a read-in parameter file (e.g., STATSGO domain), then checks are in place for LDT to stop the running process.

Now say you wish to run LIS only over the region given by  $(-97.6, 27.9), (-92.9, 31.9)$ . Since the running domain is a sub-set of the parameter domain, it is also a Latitude/Longitude domain at 1/4 deg. resolution. This gives **Run domain resolution dx:** is 0.25 and **Run domain resolution dy:** is 0.25

Since the running domain must fit onto the parameter domain, the desired running region must be expanded from  $(-97.6, 27.9), (-92.9, 31.9)$  to  $(-97.75, 27.75), (-92.75, 32.0)$ . The south-west grid-cell for the running domain is the box  $(-97.75, 27.75), (-97.5, 28.0)$ . Its center is  $(-97.625, 27.875)$ . This gives **Run domain lower left lat:** is 27.875 and **Run domain lower left lon:** is -97.625 .

The north-east grid-cell for the running domain is the box  $(-93, 31.75), (-92.75, 32.0)$ . Its center is  $(-92.875, 31.875)$ . This gives **Run domain upper right lat:** is 31.875 and **Run domain upper right lon:** is -92.875.

All together, the bounding coordinates for this sub-setted region are:

```
Run domain lower left lat: 27.875
Run domain lower left lon: -97.625
Run domain upper right lat: 31.875
Run domain upper right lon: -92.875
Run domain resolution dx: 0.25
Run domain resolution dy: 0.25
```

Note, the LIS project has defined 5 km resolution to be 0.05 deg. and 1 km resolution to be 0.01 deg. If you wish to run at 5 km or 1 km resolution, redo the above example to compute the appropriate grid-cell values.

See Figure 1 for an illustration of adjusting the running grid. See Figures 2 and 3 for an illustration of the south-west and north-east grid-cells.

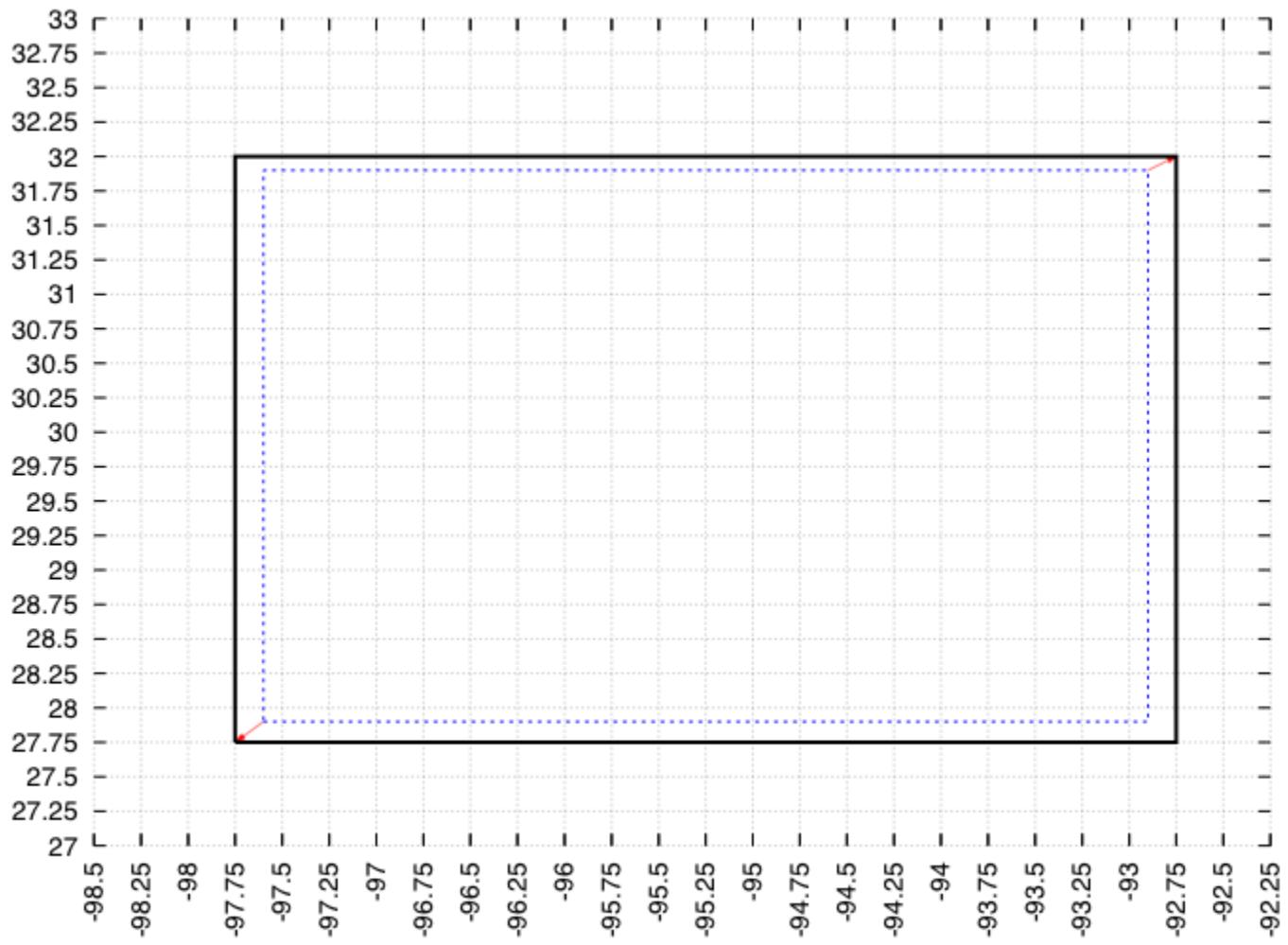


Figure 1: Illustration showing how to fit the desired running grid onto the actual grid

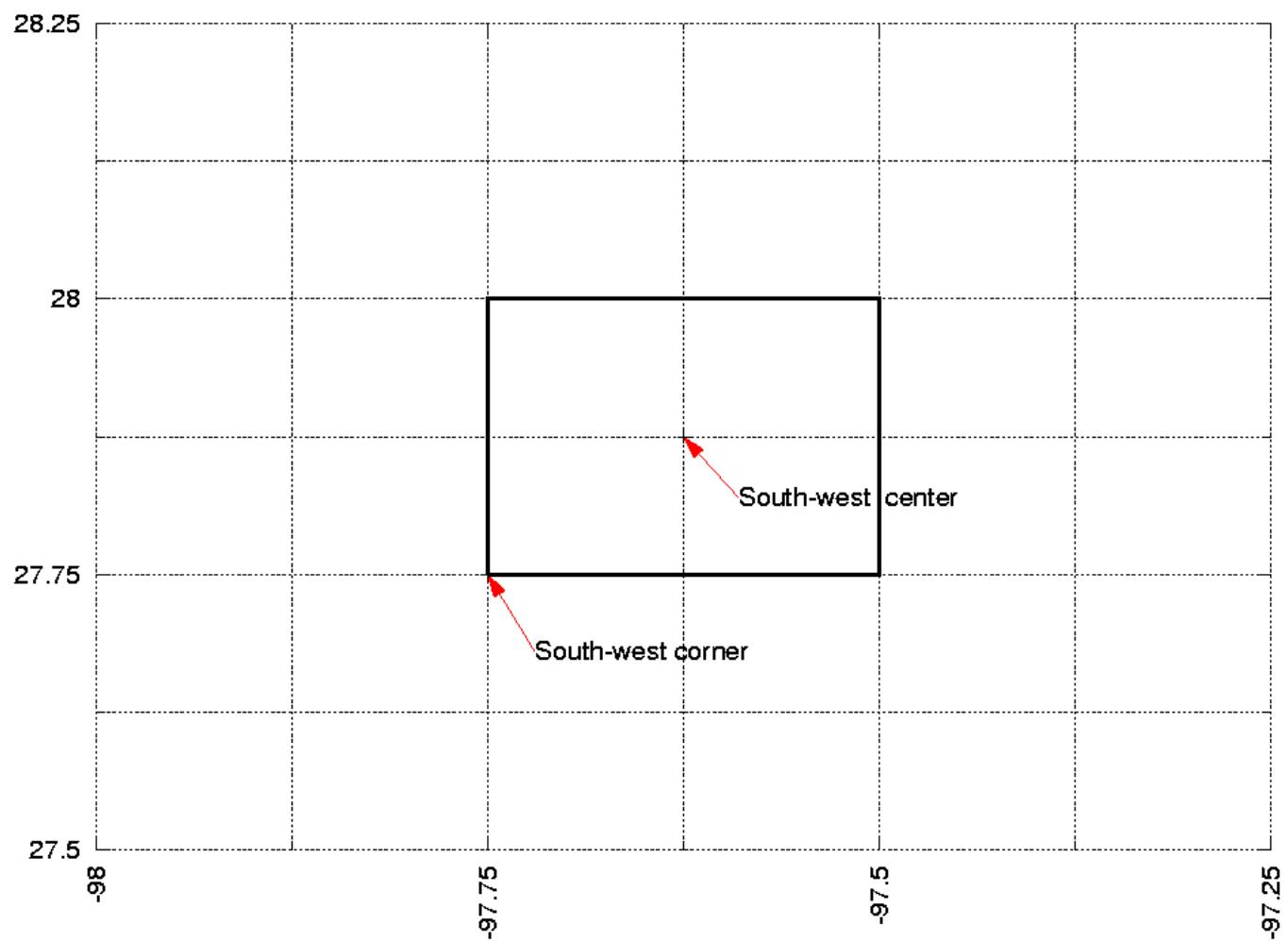


Figure 2: Illustration showing the south-west grid-cell corresponding to the example in Section B

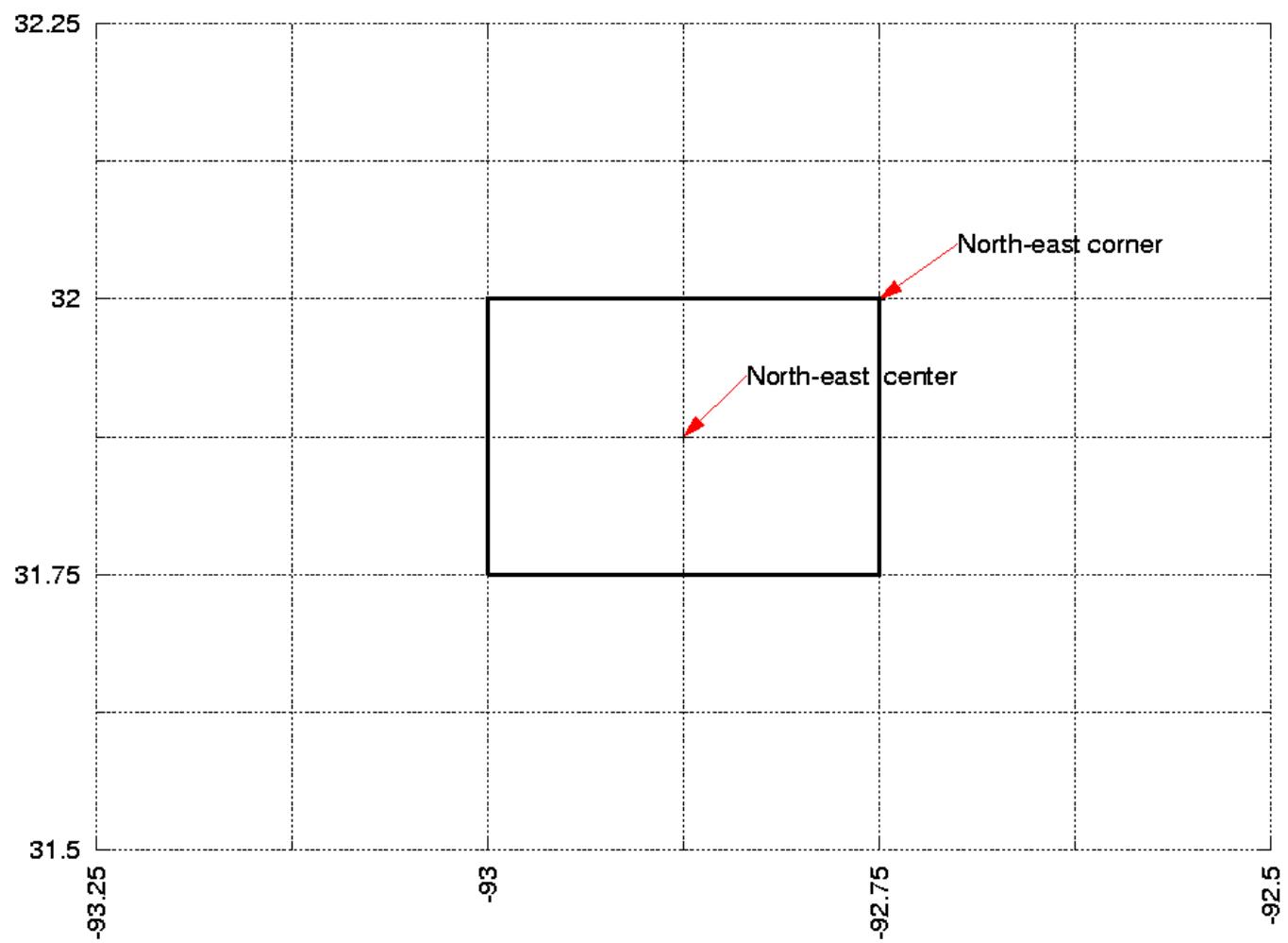


Figure 3: Illustration showing the north-east grid-cell corresponding to the example in Section B

## C Lambert Conformal Domain Example

This section describes how to compute the values for the run domain and param domain sections on a Lambert conformal projection.

Note that this projection is often used for a coupled run with the Weather Research and Forecasting (WRF) model. As such, Lambert domains are first generated when configuring WRF via WRF's preprocessing system (WPS). The domain information is then copied into LIS' *lis.config* file.

Please see WRF's User's Guide found at <http://www.mmm.ucar.edu/wrf/users/pub-doc.html> for more information.

## D Gaussian Domain Example

This section describes how to compute the values for the run domain and parameter domain sections on a Gaussian projection.

First, note that LIS' Gaussian parameter data is defined from  $-180$  to  $180$  degrees longitude and from  $-90$  to  $90$  degrees latitude. Note that the first longitude point is at  $0$ . For the T126 Gaussian projection:

```
... first grid point lat: -89.27665
... first grid point lon: 0.0
... last grid point lat: 89.27665
... last grid point lon: -0.9375
... resolution dlon: 0.9375
... number of lat circles: 95
```

If you wish to run over the whole domain defined by the parameter data domain then you simply set the values defined in the parameter domain section in the run domain section. This gives:

```
Run domain first grid point lat: -89.27665
Run domain first grid point lon: 0.0
Run domain last grid point lat: 89.27665
Run domain last grid point lon: -0.9375
Run domain resolution dlon: 0.9375
Run domain number of lat circles: 95
```

If you wish to run over a sub-domain, then you must choose longitude and latitude values that correspond to the T126 Gaussian projection. Tables of acceptable longitude and latitude values are found below.

Now say you wish to run only over the region given by  $(-97.6, 27.9), (-92.9, 31.9)$ . Since the running domain must fit on the T126 Gaussian grid, the running domain must be expanded to  $(-98.4375, 27.87391), (-91.875, 32.59830)$ . Thus the running domain specification is:

```
Run domain first grid point lat: 27.87391
Run domain first grid point lon: -98.4375
Run domain last grid point lat: 32.59830
Run domain last grid point lon: -91.875
Run domain resolution dlon: 0.9375
Run domain number of lat circles: 95
```

Table 1: Gaussian T126 acceptable longitude values

|            |            |            |             |             |
|------------|------------|------------|-------------|-------------|
| 0.000000   | 0.937500   | 1.875000   | 2.812500    | 3.750000    |
| 4.687500   | 5.625000   | 6.562500   | 7.500000    | 8.437500    |
| 9.375000   | 10.312500  | 11.250000  | 12.187500   | 13.125000   |
| 14.062500  | 15.000000  | 15.937500  | 16.875000   | 17.812500   |
| 18.750000  | 19.687500  | 20.625000  | 21.562500   | 22.500000   |
| 23.437500  | 24.375000  | 25.312500  | 26.250000   | 27.187500   |
| 28.125000  | 29.062500  | 30.000000  | 30.937500   | 31.875000   |
| 32.812500  | 33.750000  | 34.687500  | 35.625000   | 36.562500   |
| 37.500000  | 38.437500  | 39.375000  | 40.312500   | 41.250000   |
| 42.187500  | 43.125000  | 44.062500  | 45.000000   | 45.937500   |
| 46.875000  | 47.812500  | 48.750000  | 49.687500   | 50.625000   |
| 51.562500  | 52.500000  | 53.437500  | 54.375000   | 55.312500   |
| 56.250000  | 57.187500  | 58.125000  | 59.062500   | 60.000000   |
| 60.937500  | 61.875000  | 62.812500  | 63.750000   | 64.687500   |
| 65.625000  | 66.562500  | 67.500000  | 68.437500   | 69.375000   |
| 70.312500  | 71.250000  | 72.187500  | 73.125000   | 74.062500   |
| 75.000000  | 75.937500  | 76.875000  | 77.812500   | 78.750000   |
| 79.687500  | 80.625000  | 81.562500  | 82.500000   | 83.437500   |
| 84.375000  | 85.312500  | 86.250000  | 87.187500   | 88.125000   |
| 89.062500  | 90.000000  | 90.937500  | 91.875000   | 92.812500   |
| 93.750000  | 94.687500  | 95.625000  | 96.562500   | 97.500000   |
| 98.437500  | 99.375000  | 100.312500 | 101.250000  | 102.187500  |
| 103.125000 | 104.062500 | 105.000000 | 105.937500  | 106.875000  |
| 107.812500 | 108.750000 | 109.687500 | 110.625000  | 111.562500  |
| 112.500000 | 113.437500 | 114.375000 | 115.312500  | 116.250000  |
| 117.187500 | 118.125000 | 119.062500 | 120.000000  | 120.937500  |
| 121.875000 | 122.812500 | 123.750000 | 124.687500  | 125.625000  |
| 126.562500 | 127.500000 | 128.437500 | 129.375000  | 130.312500  |
| 131.250000 | 132.187500 | 133.125000 | 134.062500  | 135.000000  |
| 135.937500 | 136.875000 | 137.812500 | 138.750000  | 139.687500  |
| 140.625000 | 141.562500 | 142.500000 | 143.437500  | 144.375000  |
| 145.312500 | 146.250000 | 147.187500 | 148.125000  | 149.062500  |
| 150.000000 | 150.937500 | 151.875000 | 152.812500  | 153.750000  |
| 154.687500 | 155.625000 | 156.562500 | 157.500000  | 158.437500  |
| 159.375000 | 160.312500 | 161.250000 | 162.187500  | 163.125000  |
| 164.062500 | 165.000000 | 165.937500 | 166.875000  | 167.812500  |
| 168.750000 | 169.687500 | 170.625000 | 171.562500  | 172.500000  |
| 173.437500 | 174.375000 | 175.312500 | 176.250000  | 177.187500  |
| 178.125000 | 179.062500 | 180.000000 | -179.062500 | -178.125000 |

Table 2: Gaussian T126 acceptable longitude values (continued)

|             |             |             |             |             |
|-------------|-------------|-------------|-------------|-------------|
| -177.187500 | -176.250000 | -175.312500 | -174.375000 | -173.437500 |
| -172.500000 | -171.562500 | -170.625000 | -169.687500 | -168.750000 |
| -167.812500 | -166.875000 | -165.937500 | -165.000000 | -164.062500 |
| -163.125000 | -162.187500 | -161.250000 | -160.312500 | -159.375000 |
| -158.437500 | -157.500000 | -156.562500 | -155.625000 | -154.687500 |
| -153.750000 | -152.812500 | -151.875000 | -150.937500 | -150.000000 |
| -149.062500 | -148.125000 | -147.187500 | -146.250000 | -145.312500 |
| -144.375000 | -143.437500 | -142.500000 | -141.562500 | -140.625000 |
| -139.687500 | -138.750000 | -137.812500 | -136.875000 | -135.937500 |
| -135.000000 | -134.062500 | -133.125000 | -132.187500 | -131.250000 |
| -130.312500 | -129.375000 | -128.437500 | -127.500000 | -126.562500 |
| -125.625000 | -124.687500 | -123.750000 | -122.812500 | -121.875000 |
| -120.937500 | -120.000000 | -119.062500 | -118.125000 | -117.187500 |
| -116.250000 | -115.312500 | -114.375000 | -113.437500 | -112.500000 |
| -111.562500 | -110.625000 | -109.687500 | -108.750000 | -107.812500 |
| -106.875000 | -105.937500 | -105.000000 | -104.062500 | -103.125000 |
| -102.187500 | -101.250000 | -100.312500 | -99.375000  | -98.437500  |
| -97.500000  | -96.562500  | -95.625000  | -94.687500  | -93.750000  |
| -92.812500  | -91.875000  | -90.937500  | -90.000000  | -89.062500  |
| -88.125000  | -87.187500  | -86.250000  | -85.312500  | -84.375000  |
| -83.437500  | -82.500000  | -81.562500  | -80.625000  | -79.687500  |
| -78.750000  | -77.812500  | -76.875000  | -75.937500  | -75.000000  |
| -74.062500  | -73.125000  | -72.187500  | -71.250000  | -70.312500  |
| -69.375000  | -68.437500  | -67.500000  | -66.562500  | -65.625000  |
| -64.687500  | -63.750000  | -62.812500  | -61.875000  | -60.937500  |
| -60.000000  | -59.062500  | -58.125000  | -57.187500  | -56.250000  |
| -55.312500  | -54.375000  | -53.437500  | -52.500000  | -51.562500  |
| -50.625000  | -49.687500  | -48.750000  | -47.812500  | -46.875000  |
| -45.937500  | -45.000000  | -44.062500  | -43.125000  | -42.187500  |
| -41.250000  | -40.312500  | -39.375000  | -38.437500  | -37.500000  |
| -36.562500  | -35.625000  | -34.687500  | -33.750000  | -32.812500  |
| -31.875000  | -30.937500  | -30.000000  | -29.062500  | -28.125000  |
| -27.187500  | -26.250000  | -25.312500  | -24.375000  | -23.437500  |
| -22.500000  | -21.562500  | -20.625000  | -19.687500  | -18.750000  |
| -17.812500  | -16.875000  | -15.937500  | -15.000000  | -14.062500  |
| -13.125000  | -12.187500  | -11.250000  | -10.312500  | -9.375000   |
| -8.437500   | -7.500000   | -6.562500   | -5.625000   | -4.687500   |
| -3.750000   | -2.812500   | -1.875000   | -0.937500   |             |

Table 3: Gaussian T126 acceptable latitude values

|           |           |           |           |            |
|-----------|-----------|-----------|-----------|------------|
| -89.27665 | -88.33975 | -87.39729 | -86.45353 | -85.5093   |
| -84.56487 | -83.62028 | -82.67562 | -81.73093 | -80.78618  |
| -79.84142 | -78.89662 | -77.95183 | -77.00701 | -76.06219  |
| -75.11736 | -74.17252 | -73.22769 | -72.28285 | -71.33799  |
| -70.39314 | -69.44829 | -68.50343 | -67.55857 | -66.61371  |
| -65.66885 | -64.72399 | -63.77912 | -62.83426 | -61.88939  |
| -60.94452 | -59.99965 | -59.05478 | -58.10991 | -57.16505  |
| -56.22018 | -55.2753  | -54.33043 | -53.38556 | -52.44069  |
| -51.49581 | -50.55094 | -49.60606 | -48.66119 | -47.71632  |
| -46.77144 | -45.82657 | -44.88169 | -43.93681 | -42.99194  |
| -42.04707 | -41.10219 | -40.15731 | -39.21244 | -38.26756  |
| -37.32268 | -36.37781 | -35.43293 | -34.48805 | -33.54317  |
| -32.5983  | -31.65342 | -30.70854 | -29.76366 | -28.81879  |
| -27.87391 | -26.92903 | -25.98415 | -25.03928 | -24.0944   |
| -23.14952 | -22.20464 | -21.25977 | -20.31489 | -19.37001  |
| -18.42513 | -17.48025 | -16.53537 | -15.5905  | -14.64562  |
| -13.70074 | -12.75586 | -11.81098 | -10.8661  | -9.921225  |
| -8.976346 | -8.031467 | -7.086589 | -6.141711 | -5.196832  |
| -4.251954 | -3.307075 | -2.362196 | -1.417318 | -0.4724393 |
| 0.4724393 | 1.417318  | 2.362196  | 3.307075  | 4.251954   |
| 5.196832  | 6.141711  | 7.086589  | 8.031467  | 8.976346   |
| 9.921225  | 10.8661   | 11.81098  | 12.75586  | 13.70074   |
| 14.64562  | 15.5905   | 16.53537  | 17.48025  | 18.42513   |
| 19.37001  | 20.31489  | 21.25977  | 22.20464  | 23.14952   |
| 24.0944   | 25.03928  | 25.98415  | 26.92903  | 27.87391   |
| 28.81879  | 29.76366  | 30.70854  | 31.65342  | 32.5983    |
| 33.54317  | 34.48805  | 35.43293  | 36.37781  | 37.32268   |
| 38.26756  | 39.21244  | 40.15731  | 41.10219  | 42.04707   |
| 42.99194  | 43.93681  | 44.88169  | 45.82657  | 46.77144   |
| 47.71632  | 48.66119  | 49.60606  | 50.55094  | 51.49581   |
| 52.44069  | 53.38556  | 54.33043  | 55.2753   | 56.22018   |
| 57.16505  | 58.10991  | 59.05478  | 59.99965  | 60.94452   |
| 61.88939  | 62.83426  | 63.77912  | 64.72399  | 65.66885   |
| 66.61371  | 67.55857  | 68.50343  | 69.44829  | 70.39314   |
| 71.33799  | 72.28285  | 73.22769  | 74.17252  | 75.11736   |
| 76.06219  | 77.00701  | 77.95183  | 78.89662  | 79.84142   |
| 80.78618  | 81.73093  | 82.67562  | 83.62028  | 84.56487   |
| 85.5093   | 86.45353  | 87.39729  | 88.33975  | 89.27665   |

Table 4: Gaussian T1534 acceptable longitude values

|          |           |          |           |          |           |
|----------|-----------|----------|-----------|----------|-----------|
| 0        | 0.1171875 | 0.234375 | 0.3515625 | 0.46875  | 0.5859375 |
| 0.703125 | 0.8203125 | 0.9375   | 1.054688  | 1.171875 | 1.289062  |
| 1.40625  | 1.523438  | 1.640625 | 1.757812  | 1.875    | 1.992188  |
| 2.109375 | 2.226562  | 2.34375  | 2.460938  | 2.578125 | 2.695312  |
| 2.8125   | 2.929688  | 3.046875 | 3.164062  | 3.28125  | 3.398438  |
| 3.515625 | 3.632782  | 3.749969 | 3.867157  | 3.984344 | 4.101532  |
| 4.218719 | 4.335907  | 4.453094 | 4.570282  | 4.687469 | 4.804657  |
| 4.921844 | 5.039032  | 5.156219 | 5.273407  | 5.390594 | 5.507782  |
| 5.624969 | 5.742157  | 5.859344 | 5.976532  | 6.093719 | 6.210907  |
| 6.328094 | 6.445282  | 6.562469 | 6.679657  | 6.796844 | 6.914032  |
| 7.031219 | 7.148407  | 7.265594 | 7.382782  | 7.499969 | 7.617157  |
| 7.734344 | 7.851532  | 7.968719 | 8.085907  | 8.203094 | 8.320282  |
| 8.437469 | 8.554657  | 8.671844 | 8.789032  | 8.906219 | 9.023407  |
| 9.140594 | 9.257782  | 9.374969 | 9.492157  | 9.609344 | 9.726532  |
| 9.843719 | 9.960907  | 10.07809 | 10.19528  | 10.31247 | 10.42966  |
| 10.54684 | 10.664    | 10.78119 | 10.89838  | 11.01556 | 11.13275  |
| 11.24994 | 11.36713  | 11.48431 | 11.6015   | 11.71869 | 11.83588  |
| 11.95306 | 12.07025  | 12.18744 | 12.30463  | 12.42181 | 12.539    |
| 12.65619 | 12.77338  | 12.89056 | 13.00775  | 13.12494 | 13.24213  |
| 13.35931 | 13.4765   | 13.59369 | 13.71088  | 13.82806 | 13.94525  |
| 14.06244 | 14.17963  | 14.29681 | 14.414    | 14.53119 | 14.64838  |
| 14.76556 | 14.88275  | 14.99994 | 15.11713  | 15.23431 | 15.3515   |
| 15.46869 | 15.58588  | 15.70306 | 15.82025  | 15.93744 | 16.05463  |
| 16.17181 | 16.289    | 16.40619 | 16.52338  | 16.64056 | 16.75775  |
| 16.87494 | 16.99213  | 17.10931 | 17.2265   | 17.34369 | 17.46088  |
| 17.57806 | 17.69525  | 17.81244 | 17.92963  | 18.04681 | 18.16397  |
| 18.28116 | 18.39835  | 18.51553 | 18.63272  | 18.74991 | 18.8671   |
| 18.98428 | 19.10147  | 19.21866 | 19.33585  | 19.45303 | 19.57022  |
| 19.68741 | 19.8046   | 19.92178 | 20.03897  | 20.15616 | 20.27335  |
| 20.39053 | 20.50772  | 20.62491 | 20.7421   | 20.85928 | 20.97647  |
| 21.09366 | 21.21085  | 21.32803 | 21.44522  | 21.56241 | 21.6796   |
| 21.79678 | 21.91397  | 22.03116 | 22.14835  | 22.26553 | 22.38272  |
| 22.49991 | 22.6171   | 22.73428 | 22.85147  | 22.96866 | 23.08585  |
| 23.20303 | 23.32022  | 23.43741 | 23.5546   | 23.67178 | 23.78897  |
| 23.90616 | 24.02335  | 24.14053 | 24.25772  | 24.37491 | 24.4921   |
| 24.60928 | 24.72647  | 24.84366 | 24.96082  | 25.078   | 25.19519  |
| 25.31238 | 25.42957  | 25.54675 | 25.66394  | 25.78113 | 25.89832  |
| 26.0155  | 26.13269  | 26.24988 | 26.36707  | 26.48425 | 26.60144  |
| 26.71863 | 26.83582  | 26.953   | 27.07019  | 27.18738 | 27.30457  |
| 27.42175 | 27.53894  | 27.65613 | 27.77332  | 27.8905  | 28.00769  |
| 28.12488 | 28.24207  | 28.35925 | 28.47644  | 28.59363 | 28.71082  |
| 28.828   | 28.94519  | 29.06238 | 29.17957  | 29.29675 | 29.41394  |
| 29.53113 | 29.64832  | 29.7655  | 29.88269  | 29.99988 | 30.11707  |

Table 5: Gaussian T1534 acceptable longitude values (continued)

|          |          |          |          |          |          |
|----------|----------|----------|----------|----------|----------|
| 30.23425 | 30.35144 | 30.46863 | 30.58582 | 30.703   | 30.82019 |
| 30.93738 | 31.05457 | 31.17175 | 31.28894 | 31.40613 | 31.52332 |
| 31.6405  | 31.75769 | 31.87488 | 31.99207 | 32.10925 | 32.22644 |
| 32.34363 | 32.46082 | 32.578   | 32.69516 | 32.81235 | 32.92953 |
| 33.04672 | 33.16391 | 33.2811  | 33.39828 | 33.51547 | 33.63266 |
| 33.74985 | 33.86703 | 33.98422 | 34.10141 | 34.2186  | 34.33578 |
| 34.45297 | 34.57016 | 34.68735 | 34.80453 | 34.92172 | 35.03891 |
| 35.1561  | 35.27328 | 35.39047 | 35.50766 | 35.62485 | 35.74203 |
| 35.85922 | 35.97641 | 36.0936  | 36.21078 | 36.32797 | 36.44516 |
| 36.56235 | 36.67953 | 36.79672 | 36.91391 | 37.0311  | 37.14828 |
| 37.26547 | 37.38266 | 37.49985 | 37.61703 | 37.73422 | 37.85141 |
| 37.9686  | 38.08578 | 38.20297 | 38.32016 | 38.43735 | 38.55453 |
| 38.67172 | 38.78891 | 38.9061  | 39.02325 | 39.14044 | 39.25763 |
| 39.37482 | 39.492   | 39.60919 | 39.72638 | 39.84357 | 39.96075 |
| 40.07794 | 40.19513 | 40.31232 | 40.4295  | 40.54669 | 40.66388 |
| 40.78107 | 40.89825 | 41.01544 | 41.13263 | 41.24982 | 41.367   |
| 41.48419 | 41.60138 | 41.71857 | 41.83575 | 41.95294 | 42.07013 |
| 42.18732 | 42.3045  | 42.42169 | 42.53888 | 42.65607 | 42.77325 |
| 42.89044 | 43.00763 | 43.12482 | 43.242   | 43.35919 | 43.47638 |
| 43.59357 | 43.71075 | 43.82794 | 43.94513 | 44.06232 | 44.1795  |
| 44.29669 | 44.41388 | 44.53107 | 44.64825 | 44.76544 | 44.88263 |
| 44.99982 | 45.117   | 45.23419 | 45.35138 | 45.46857 | 45.58575 |
| 45.70294 | 45.82013 | 45.93732 | 46.0545  | 46.17169 | 46.28888 |
| 46.40607 | 46.52325 | 46.64044 | 46.75763 | 46.87482 | 46.992   |
| 47.10916 | 47.22635 | 47.34354 | 47.46072 | 47.57791 | 47.6951  |
| 47.81229 | 47.92947 | 48.04666 | 48.16385 | 48.28104 | 48.39822 |
| 48.51541 | 48.6326  | 48.74979 | 48.86697 | 48.98416 | 49.10135 |
| 49.21854 | 49.33572 | 49.45291 | 49.5701  | 49.68729 | 49.80447 |
| 49.92166 | 50.03885 | 50.15604 | 50.27322 | 50.39041 | 50.5076  |
| 50.62479 | 50.74197 | 50.85916 | 50.97635 | 51.09354 | 51.21072 |
| 51.32791 | 51.4451  | 51.56229 | 51.67947 | 51.79666 | 51.91385 |
| 52.03104 | 52.14822 | 52.26541 | 52.3826  | 52.49979 | 52.61697 |
| 52.73416 | 52.85135 | 52.96854 | 53.08572 | 53.20291 | 53.32007 |
| 53.43726 | 53.55444 | 53.67163 | 53.78882 | 53.90601 | 54.02319 |
| 54.14038 | 54.25757 | 54.37476 | 54.49194 | 54.60913 | 54.72632 |
| 54.84351 | 54.96069 | 55.07788 | 55.19507 | 55.31226 | 55.42944 |
| 55.54663 | 55.66382 | 55.78101 | 55.89819 | 56.01538 | 56.13257 |
| 56.24976 | 56.36694 | 56.48413 | 56.60132 | 56.71851 | 56.83569 |
| 56.95288 | 57.07007 | 57.18726 | 57.30444 | 57.42163 | 57.53882 |
| 57.65601 | 57.77319 | 57.89038 | 58.00757 | 58.12476 | 58.24194 |
| 58.35913 | 58.47632 | 58.59351 | 58.71069 | 58.82788 | 58.94507 |
| 59.06226 | 59.17944 | 59.29663 | 59.41382 | 59.53101 | 59.64819 |
| 59.76538 | 59.88257 | 59.99976 | 60.11694 | 60.23413 | 60.35132 |

Table 6: Gaussian T1534 acceptable longitude values (continued)

|          |          |          |          |          |          |
|----------|----------|----------|----------|----------|----------|
| 60.46851 | 60.58569 | 60.70288 | 60.82007 | 60.93726 | 61.05444 |
| 61.17163 | 61.28882 | 61.40598 | 61.52316 | 61.64035 | 61.75754 |
| 61.87473 | 61.99191 | 62.1091  | 62.22629 | 62.34348 | 62.46066 |
| 62.57785 | 62.69504 | 62.81223 | 62.92941 | 63.0466  | 63.16379 |
| 63.28098 | 63.39816 | 63.51535 | 63.63254 | 63.74973 | 63.86691 |
| 63.9841  | 64.10129 | 64.21848 | 64.33566 | 64.45285 | 64.57004 |
| 64.68723 | 64.80441 | 64.9216  | 65.03879 | 65.15598 | 65.27316 |
| 65.39035 | 65.50754 | 65.62473 | 65.74191 | 65.8591  | 65.97629 |
| 66.09348 | 66.21066 | 66.32785 | 66.44504 | 66.56223 | 66.67941 |
| 66.7966  | 66.91379 | 67.03098 | 67.14816 | 67.26532 | 67.38251 |
| 67.49969 | 67.61688 | 67.73407 | 67.85126 | 67.96844 | 68.08563 |
| 68.20282 | 68.32001 | 68.43719 | 68.55438 | 68.67157 | 68.78876 |
| 68.90594 | 69.02313 | 69.14032 | 69.25751 | 69.37469 | 69.49188 |
| 69.60907 | 69.72626 | 69.84344 | 69.96063 | 70.07782 | 70.19501 |
| 70.31219 | 70.42938 | 70.54657 | 70.66376 | 70.78094 | 70.89813 |
| 71.01532 | 71.13251 | 71.24969 | 71.36688 | 71.48407 | 71.60126 |
| 71.71844 | 71.83563 | 71.95282 | 72.07001 | 72.18719 | 72.30438 |
| 72.42157 | 72.53876 | 72.65594 | 72.77313 | 72.89032 | 73.00751 |
| 73.12469 | 73.24188 | 73.35907 | 73.47626 | 73.59344 | 73.71063 |
| 73.82782 | 73.94501 | 74.06219 | 74.17938 | 74.29657 | 74.41376 |
| 74.53094 | 74.64813 | 74.76532 | 74.88251 | 74.99969 | 75.11688 |
| 75.23407 | 75.35126 | 75.46844 | 75.58563 | 75.70282 | 75.82001 |
| 75.93719 | 76.05438 | 76.17154 | 76.28873 | 76.40591 | 76.5231  |
| 76.64029 | 76.75748 | 76.87466 | 76.99185 | 77.10904 | 77.22623 |
| 77.34341 | 77.4606  | 77.57779 | 77.69498 | 77.81216 | 77.92935 |
| 78.04654 | 78.16373 | 78.28091 | 78.3981  | 78.51529 | 78.63248 |
| 78.74966 | 78.86685 | 78.98404 | 79.10123 | 79.21841 | 79.3356  |
| 79.45279 | 79.56998 | 79.68716 | 79.80435 | 79.92154 | 80.03873 |
| 80.15591 | 80.2731  | 80.39029 | 80.50748 | 80.62466 | 80.74185 |
| 80.85904 | 80.97623 | 81.09341 | 81.2106  | 81.32779 | 81.44498 |
| 81.56213 | 81.67932 | 81.79651 | 81.9137  | 82.03088 | 82.14807 |
| 82.26526 | 82.38245 | 82.49963 | 82.61682 | 82.73401 | 82.8512  |
| 82.96838 | 83.08557 | 83.20276 | 83.31995 | 83.43713 | 83.55432 |
| 83.67151 | 83.7887  | 83.90588 | 84.02307 | 84.14026 | 84.25745 |
| 84.37463 | 84.49182 | 84.60901 | 84.7262  | 84.84338 | 84.96057 |
| 85.07776 | 85.19495 | 85.31213 | 85.42932 | 85.54651 | 85.6637  |
| 85.78088 | 85.89807 | 86.01526 | 86.13245 | 86.24963 | 86.36682 |
| 86.48401 | 86.6012  | 86.71838 | 86.83557 | 86.95276 | 87.06995 |
| 87.18713 | 87.30432 | 87.42151 | 87.5387  | 87.65588 | 87.77307 |
| 87.89026 | 88.00745 | 88.12463 | 88.24182 | 88.35901 | 88.4762  |
| 88.59338 | 88.71057 | 88.82776 | 88.94495 | 89.06213 | 89.17932 |
| 89.29651 | 89.4137  | 89.53088 | 89.64807 | 89.76526 | 89.88245 |
| 89.99963 | 90.11682 | 90.23401 | 90.3512  | 90.46835 | 90.58554 |

Table 7: Gaussian T1534 acceptable longitude values (continued)

|          |          |          |          |          |          |
|----------|----------|----------|----------|----------|----------|
| 90.70273 | 90.81992 | 90.9371  | 91.05429 | 91.17148 | 91.28867 |
| 91.40585 | 91.52304 | 91.64023 | 91.75742 | 91.8746  | 91.99179 |
| 92.10898 | 92.22617 | 92.34335 | 92.46054 | 92.57773 | 92.69492 |
| 92.8121  | 92.92929 | 93.04648 | 93.16367 | 93.28085 | 93.39804 |
| 93.51523 | 93.63242 | 93.7496  | 93.86679 | 93.98398 | 94.10117 |
| 94.21835 | 94.33554 | 94.45273 | 94.56992 | 94.6871  | 94.80429 |
| 94.92148 | 95.03867 | 95.15585 | 95.27304 | 95.39023 | 95.50742 |
| 95.6246  | 95.74179 | 95.85895 | 95.97614 | 96.09332 | 96.21051 |
| 96.3277  | 96.44489 | 96.56207 | 96.67926 | 96.79645 | 96.91364 |
| 97.03082 | 97.14801 | 97.2652  | 97.38239 | 97.49957 | 97.61676 |
| 97.73395 | 97.85114 | 97.96832 | 98.08551 | 98.2027  | 98.31989 |
| 98.43707 | 98.55426 | 98.67145 | 98.78864 | 98.90582 | 99.02301 |
| 99.1402  | 99.25739 | 99.37457 | 99.49176 | 99.60895 | 99.72614 |
| 99.84332 | 99.96051 | 100.0777 | 100.1949 | 100.3121 | 100.4293 |
| 100.5464 | 100.6636 | 100.7808 | 100.898  | 101.0152 | 101.1324 |
| 101.2496 | 101.3668 | 101.4839 | 101.6011 | 101.7183 | 101.8355 |
| 101.9527 | 102.0699 | 102.1871 | 102.3043 | 102.4214 | 102.5386 |
| 102.6558 | 102.773  | 102.8902 | 103.0074 | 103.1246 | 103.2418 |
| 103.3589 | 103.4761 | 103.5933 | 103.7105 | 103.8277 | 103.9449 |
| 104.0621 | 104.1793 | 104.2964 | 104.4136 | 104.5308 | 104.648  |
| 104.7652 | 104.8824 | 104.9995 | 105.1167 | 105.2339 | 105.3511 |
| 105.4683 | 105.5855 | 105.7027 | 105.8199 | 105.937  | 106.0542 |
| 106.1714 | 106.2886 | 106.4058 | 106.523  | 106.6402 | 106.7574 |
| 106.8745 | 106.9917 | 107.1089 | 107.2261 | 107.3433 | 107.4605 |
| 107.5777 | 107.6949 | 107.812  | 107.9292 | 108.0464 | 108.1636 |
| 108.2808 | 108.398  | 108.5152 | 108.6324 | 108.7495 | 108.8667 |
| 108.9839 | 109.1011 | 109.2183 | 109.3355 | 109.4527 | 109.5699 |
| 109.687  | 109.8042 | 109.9214 | 110.0386 | 110.1558 | 110.2729 |
| 110.3901 | 110.5073 | 110.6245 | 110.7417 | 110.8589 | 110.9761 |
| 111.0933 | 111.2104 | 111.3276 | 111.4448 | 111.562  | 111.6792 |
| 111.7964 | 111.9136 | 112.0308 | 112.1479 | 112.2651 | 112.3823 |
| 112.4995 | 112.6167 | 112.7339 | 112.8511 | 112.9683 | 113.0854 |
| 113.2026 | 113.3198 | 113.437  | 113.5542 | 113.6714 | 113.7886 |
| 113.9058 | 114.0229 | 114.1401 | 114.2573 | 114.3745 | 114.4917 |
| 114.6089 | 114.7261 | 114.8433 | 114.9604 | 115.0776 | 115.1948 |
| 115.312  | 115.4292 | 115.5464 | 115.6636 | 115.7808 | 115.8979 |
| 116.0151 | 116.1323 | 116.2495 | 116.3667 | 116.4839 | 116.6011 |
| 116.7183 | 116.8354 | 116.9526 | 117.0698 | 117.187  | 117.3042 |
| 117.4214 | 117.5386 | 117.6558 | 117.7729 | 117.8901 | 118.0073 |
| 118.1245 | 118.2417 | 118.3589 | 118.4761 | 118.5933 | 118.7104 |
| 118.8276 | 118.9448 | 119.062  | 119.1792 | 119.2964 | 119.4135 |
| 119.5307 | 119.6479 | 119.7651 | 119.8823 | 119.9995 | 120.1167 |
| 120.2339 | 120.351  | 120.4682 | 120.5854 | 120.7026 | 120.8198 |

Table 8: Gaussian T1534 acceptable longitude values (continued)

|          |          |          |          |          |          |
|----------|----------|----------|----------|----------|----------|
| 120.937  | 121.0542 | 121.1714 | 121.2885 | 121.4057 | 121.5229 |
| 121.6401 | 121.7573 | 121.8745 | 121.9917 | 122.1089 | 122.226  |
| 122.3432 | 122.4604 | 122.5776 | 122.6948 | 122.812  | 122.9292 |
| 123.0464 | 123.1635 | 123.2807 | 123.3979 | 123.5151 | 123.6323 |
| 123.7495 | 123.8667 | 123.9839 | 124.101  | 124.2182 | 124.3354 |
| 124.4526 | 124.5698 | 124.687  | 124.8041 | 124.9213 | 125.0385 |
| 125.1557 | 125.2729 | 125.3901 | 125.5073 | 125.6245 | 125.7416 |
| 125.8588 | 125.976  | 126.0932 | 126.2104 | 126.3276 | 126.4448 |
| 126.562  | 126.6791 | 126.7963 | 126.9135 | 127.0307 | 127.1479 |
| 127.2651 | 127.3823 | 127.4995 | 127.6166 | 127.7338 | 127.851  |
| 127.9682 | 128.0854 | 128.2026 | 128.3198 | 128.437  | 128.5541 |
| 128.6713 | 128.7885 | 128.9057 | 129.0229 | 129.1401 | 129.2573 |
| 129.3745 | 129.4916 | 129.6088 | 129.726  | 129.8432 | 129.9604 |
| 130.0776 | 130.1948 | 130.312  | 130.4291 | 130.5463 | 130.6635 |
| 130.7807 | 130.8979 | 131.0151 | 131.1323 | 131.2495 | 131.3666 |
| 131.4838 | 131.601  | 131.7182 | 131.8354 | 131.9526 | 132.0698 |
| 132.187  | 132.3041 | 132.4213 | 132.5385 | 132.6557 | 132.7729 |
| 132.8901 | 133.0073 | 133.1245 | 133.2416 | 133.3588 | 133.476  |
| 133.5932 | 133.7104 | 133.8276 | 133.9448 | 134.062  | 134.1791 |
| 134.2963 | 134.4135 | 134.5307 | 134.6479 | 134.765  | 134.8822 |
| 134.9994 | 135.1166 | 135.2338 | 135.351  | 135.4682 | 135.5854 |
| 135.7025 | 135.8197 | 135.9369 | 136.0541 | 136.1713 | 136.2885 |
| 136.4057 | 136.5229 | 136.64   | 136.7572 | 136.8744 | 136.9916 |
| 137.1088 | 137.226  | 137.3432 | 137.4604 | 137.5775 | 137.6947 |
| 137.8119 | 137.9291 | 138.0463 | 138.1635 | 138.2806 | 138.3978 |
| 138.515  | 138.6322 | 138.7494 | 138.8666 | 138.9838 | 139.101  |
| 139.2181 | 139.3353 | 139.4525 | 139.5697 | 139.6869 | 139.8041 |
| 139.9213 | 140.0385 | 140.1556 | 140.2728 | 140.39   | 140.5072 |
| 140.6244 | 140.7416 | 140.8588 | 140.976  | 141.0931 | 141.2103 |
| 141.3275 | 141.4447 | 141.5619 | 141.6791 | 141.7963 | 141.9135 |
| 142.0306 | 142.1478 | 142.265  | 142.3822 | 142.4994 | 142.6166 |
| 142.7338 | 142.851  | 142.9681 | 143.0853 | 143.2025 | 143.3197 |
| 143.4369 | 143.5541 | 143.6713 | 143.7885 | 143.9056 | 144.0228 |
| 144.14   | 144.2572 | 144.3744 | 144.4916 | 144.6088 | 144.726  |
| 144.8431 | 144.9603 | 145.0775 | 145.1947 | 145.3119 | 145.4291 |
| 145.5463 | 145.6635 | 145.7806 | 145.8978 | 146.015  | 146.1322 |
| 146.2494 | 146.3666 | 146.4838 | 146.601  | 146.7181 | 146.8353 |
| 146.9525 | 147.0697 | 147.1869 | 147.3041 | 147.4213 | 147.5385 |
| 147.6556 | 147.7728 | 147.89   | 148.0072 | 148.1244 | 148.2416 |
| 148.3588 | 148.476  | 148.5931 | 148.7103 | 148.8275 | 148.9447 |
| 149.0619 | 149.179  | 149.2962 | 149.4134 | 149.5306 | 149.6478 |
| 149.765  | 149.8822 | 149.9994 | 150.1165 | 150.2337 | 150.3509 |
| 150.4681 | 150.5853 | 150.7025 | 150.8197 | 150.9369 | 151.054  |

Table 9: Gaussian T1534 acceptable longitude values (continued)

|           |           |           |           |           |           |
|-----------|-----------|-----------|-----------|-----------|-----------|
| 151.1712  | 151.2884  | 151.4056  | 151.5228  | 151.64    | 151.7572  |
| 151.8744  | 151.9915  | 152.1088  | 152.226   | 152.3431  | 152.4603  |
| 152.5775  | 152.6946  | 152.8118  | 152.929   | 153.0462  | 153.1634  |
| 153.2806  | 153.3978  | 153.515   | 153.6321  | 153.7493  | 153.8665  |
| 153.9837  | 154.1009  | 154.2181  | 154.3353  | 154.4525  | 154.5696  |
| 154.6868  | 154.804   | 154.9212  | 155.0384  | 155.1556  | 155.2728  |
| 155.39    | 155.5071  | 155.6243  | 155.7415  | 155.8587  | 155.9759  |
| 156.0931  | 156.2103  | 156.3275  | 156.4446  | 156.5618  | 156.679   |
| 156.7962  | 156.9134  | 157.0306  | 157.1478  | 157.265   | 157.3821  |
| 157.4993  | 157.6165  | 157.7337  | 157.8509  | 157.9681  | 158.0853  |
| 158.2025  | 158.3196  | 158.4368  | 158.554   | 158.6712  | 158.7884  |
| 158.9056  | 159.0228  | 159.14    | 159.2571  | 159.3743  | 159.4915  |
| 159.6087  | 159.7259  | 159.8431  | 159.9603  | 160.0775  | 160.1946  |
| 160.3118  | 160.429   | 160.5462  | 160.6634  | 160.7806  | 160.8978  |
| 161.015   | 161.1321  | 161.2493  | 161.3665  | 161.4837  | 161.6009  |
| 161.7181  | 161.8353  | 161.9525  | 162.0696  | 162.1868  | 162.304   |
| 162.4212  | 162.5384  | 162.6556  | 162.7728  | 162.89    | 163.0071  |
| 163.1243  | 163.2415  | 163.3586  | 163.4758  | 163.593   | 163.7102  |
| 163.8274  | 163.9446  | 164.0618  | 164.179   | 164.2961  | 164.4133  |
| 164.5305  | 164.6477  | 164.7649  | 164.8821  | 164.9993  | 165.1165  |
| 165.2336  | 165.3508  | 165.468   | 165.5852  | 165.7024  | 165.8196  |
| 165.9368  | 166.054   | 166.1711  | 166.2883  | 166.4055  | 166.5227  |
| 166.6399  | 166.7571  | 166.8743  | 166.9915  | 167.1086  | 167.2258  |
| 167.343   | 167.4602  | 167.5774  | 167.6946  | 167.8118  | 167.929   |
| 168.0461  | 168.1633  | 168.2805  | 168.3977  | 168.5149  | 168.6321  |
| 168.7493  | 168.8665  | 168.9836  | 169.1008  | 169.218   | 169.3352  |
| 169.4524  | 169.5696  | 169.6868  | 169.804   | 169.9211  | 170.0383  |
| 170.1555  | 170.2727  | 170.3899  | 170.5071  | 170.6243  | 170.7415  |
| 170.8586  | 170.9758  | 171.093   | 171.2102  | 171.3274  | 171.4446  |
| 171.5618  | 171.679   | 171.7961  | 171.9133  | 172.0305  | 172.1477  |
| 172.2649  | 172.3821  | 172.4993  | 172.6165  | 172.7336  | 172.8508  |
| 172.968   | 173.0852  | 173.2024  | 173.3196  | 173.4368  | 173.554   |
| 173.6711  | 173.7883  | 173.9055  | 174.0227  | 174.1399  | 174.2571  |
| 174.3743  | 174.4915  | 174.6086  | 174.7258  | 174.843   | 174.9602  |
| 175.0774  | 175.1946  | 175.3118  | 175.429   | 175.5461  | 175.6633  |
| 175.7805  | 175.8977  | 176.0149  | 176.1321  | 176.2493  | 176.3665  |
| 176.4836  | 176.6008  | 176.718   | 176.8352  | 176.9524  | 177.0696  |
| 177.1868  | 177.304   | 177.4211  | 177.5383  | 177.6555  | 177.7727  |
| 177.8899  | 178.0071  | 178.1243  | 178.2415  | 178.3586  | 178.4758  |
| 178.593   | 178.7102  | 178.8274  | 178.9446  | 179.0618  | 179.179   |
| 179.2961  | 179.4133  | 179.5305  | 179.6477  | 179.7649  | 179.8821  |
| 179.9993  | -179.8835 | -179.7664 | -179.6492 | -179.532  | -179.4148 |
| -179.2976 | -179.1804 | -179.0633 | -178.9461 | -178.8289 | -178.7117 |

Table 10: Gaussian T1534 acceptable longitude values (continued)

|           |           |           |           |           |           |
|-----------|-----------|-----------|-----------|-----------|-----------|
| -178.5945 | -178.4774 | -178.3602 | -178.243  | -178.1258 | -178.0086 |
| -177.8914 | -177.7742 | -177.657  | -177.5399 | -177.4227 | -177.3055 |
| -177.1883 | -177.0711 | -176.9539 | -176.8367 | -176.7195 | -176.6024 |
| -176.4852 | -176.368  | -176.2508 | -176.1336 | -176.0164 | -175.8992 |
| -175.782  | -175.6649 | -175.5477 | -175.4305 | -175.3133 | -175.1961 |
| -175.0789 | -174.9617 | -174.8445 | -174.7274 | -174.6102 | -174.493  |
| -174.3758 | -174.2586 | -174.1414 | -174.0242 | -173.907  | -173.7899 |
| -173.6727 | -173.5555 | -173.4383 | -173.3211 | -173.2039 | -173.0867 |
| -172.9695 | -172.8524 | -172.7352 | -172.618  | -172.5008 | -172.3836 |
| -172.2664 | -172.1492 | -172.032  | -171.9149 | -171.7977 | -171.6805 |
| -171.5633 | -171.4461 | -171.3289 | -171.2117 | -171.0945 | -170.9774 |
| -170.8602 | -170.743  | -170.6258 | -170.5086 | -170.3914 | -170.2742 |
| -170.157  | -170.0399 | -169.9227 | -169.8055 | -169.6883 | -169.5711 |
| -169.4539 | -169.3367 | -169.2195 | -169.1024 | -168.9852 | -168.868  |
| -168.7508 | -168.6336 | -168.5164 | -168.3992 | -168.2821 | -168.1649 |
| -168.0477 | -167.9305 | -167.8134 | -167.6962 | -167.579  | -167.4618 |
| -167.3446 | -167.2274 | -167.1102 | -166.993  | -166.8759 | -166.7587 |
| -166.6415 | -166.5243 | -166.4071 | -166.2899 | -166.1727 | -166.0555 |
| -165.9384 | -165.8212 | -165.704  | -165.5868 | -165.4696 | -165.3524 |
| -165.2352 | -165.118  | -165.0009 | -164.8837 | -164.7665 | -164.6493 |
| -164.5321 | -164.4149 | -164.2977 | -164.1805 | -164.0634 | -163.9462 |
| -163.829  | -163.7118 | -163.5946 | -163.4774 | -163.3602 | -163.243  |
| -163.1259 | -163.0087 | -162.8915 | -162.7743 | -162.6571 | -162.5399 |
| -162.4227 | -162.3055 | -162.1884 | -162.0712 | -161.954  | -161.8368 |
| -161.7196 | -161.6024 | -161.4852 | -161.368  | -161.2509 | -161.1337 |
| -161.0165 | -160.8993 | -160.7821 | -160.6649 | -160.5477 | -160.4305 |
| -160.3134 | -160.1962 | -160.079  | -159.9618 | -159.8446 | -159.7274 |
| -159.6102 | -159.493  | -159.3759 | -159.2587 | -159.1415 | -159.0243 |
| -158.9071 | -158.7899 | -158.6727 | -158.5555 | -158.4384 | -158.3212 |
| -158.204  | -158.0868 | -157.9696 | -157.8524 | -157.7352 | -157.618  |
| -157.5009 | -157.3837 | -157.2665 | -157.1493 | -157.0321 | -156.9149 |
| -156.7977 | -156.6805 | -156.5634 | -156.4462 | -156.329  | -156.2118 |
| -156.0946 | -155.9774 | -155.8602 | -155.743  | -155.6259 | -155.5087 |
| -155.3915 | -155.2743 | -155.1571 | -155.0399 | -154.9227 | -154.8055 |
| -154.6884 | -154.5712 | -154.454  | -154.3368 | -154.2196 | -154.1024 |
| -153.9852 | -153.868  | -153.7509 | -153.6337 | -153.5165 | -153.3993 |
| -153.2821 | -153.1649 | -153.0477 | -152.9305 | -152.8134 | -152.6962 |
| -152.579  | -152.4618 | -152.3446 | -152.2274 | -152.1102 | -151.993  |
| -151.8759 | -151.7587 | -151.6415 | -151.5243 | -151.4071 | -151.2899 |
| -151.1727 | -151.0555 | -150.9384 | -150.8212 | -150.704  | -150.5868 |
| -150.4696 | -150.3525 | -150.2353 | -150.1181 | -150.0009 | -149.8837 |
| -149.7665 | -149.6494 | -149.5322 | -149.415  | -149.2978 | -149.1806 |
| -149.0634 | -148.9462 | -148.829  | -148.7119 | -148.5947 | -148.4775 |

Table 11: Gaussian T1534 acceptable longitude values (continued)

|           |           |           |           |           |           |
|-----------|-----------|-----------|-----------|-----------|-----------|
| -148.3603 | -148.2431 | -148.1259 | -148.0087 | -147.8915 | -147.7744 |
| -147.6572 | -147.54   | -147.4228 | -147.3056 | -147.1884 | -147.0712 |
| -146.954  | -146.8369 | -146.7197 | -146.6025 | -146.4853 | -146.3681 |
| -146.2509 | -146.1337 | -146.0165 | -145.8994 | -145.7822 | -145.665  |
| -145.5478 | -145.4306 | -145.3134 | -145.1962 | -145.079  | -144.9619 |
| -144.8447 | -144.7275 | -144.6103 | -144.4931 | -144.3759 | -144.2587 |
| -144.1415 | -144.0244 | -143.9072 | -143.79   | -143.6728 | -143.5556 |
| -143.4384 | -143.3212 | -143.204  | -143.0869 | -142.9697 | -142.8525 |
| -142.7353 | -142.6181 | -142.5009 | -142.3837 | -142.2665 | -142.1494 |
| -142.0322 | -141.915  | -141.7978 | -141.6806 | -141.5634 | -141.4462 |
| -141.329  | -141.2119 | -141.0947 | -140.9775 | -140.8603 | -140.7431 |
| -140.6259 | -140.5087 | -140.3915 | -140.2744 | -140.1572 | -140.04   |
| -139.9228 | -139.8056 | -139.6885 | -139.5713 | -139.4541 | -139.3369 |
| -139.2197 | -139.1025 | -138.9854 | -138.8682 | -138.751  | -138.6338 |
| -138.5166 | -138.3994 | -138.2822 | -138.165  | -138.0479 | -137.9307 |
| -137.8135 | -137.6963 | -137.5791 | -137.4619 | -137.3447 | -137.2275 |
| -137.1104 | -136.9932 | -136.876  | -136.7588 | -136.6416 | -136.5244 |
| -136.4072 | -136.29   | -136.1729 | -136.0557 | -135.9385 | -135.8213 |
| -135.7041 | -135.5869 | -135.4697 | -135.3525 | -135.2354 | -135.1182 |
| -135.001  | -134.8838 | -134.7666 | -134.6494 | -134.5322 | -134.415  |
| -134.2979 | -134.1807 | -134.0635 | -133.9463 | -133.8291 | -133.7119 |
| -133.5947 | -133.4775 | -133.3604 | -133.2432 | -133.126  | -133.0088 |
| -132.8916 | -132.7744 | -132.6572 | -132.54   | -132.4229 | -132.3057 |
| -132.1885 | -132.0713 | -131.9541 | -131.8369 | -131.7197 | -131.6025 |
| -131.4854 | -131.3682 | -131.251  | -131.1338 | -131.0166 | -130.8994 |
| -130.7822 | -130.665  | -130.5479 | -130.4307 | -130.3135 | -130.1963 |
| -130.0791 | -129.9619 | -129.8447 | -129.7275 | -129.6104 | -129.4932 |
| -129.376  | -129.2588 | -129.1416 | -129.0244 | -128.9072 | -128.79   |
| -128.6729 | -128.5557 | -128.4385 | -128.3213 | -128.2041 | -128.0869 |
| -127.9697 | -127.8525 | -127.7354 | -127.6182 | -127.501  | -127.3838 |
| -127.2666 | -127.1494 | -127.0322 | -126.915  | -126.7979 | -126.6807 |
| -126.5635 | -126.4463 | -126.3291 | -126.2119 | -126.0947 | -125.9775 |
| -125.8604 | -125.7432 | -125.626  | -125.5088 | -125.3916 | -125.2744 |
| -125.1572 | -125.04   | -124.9229 | -124.8057 | -124.6885 | -124.5713 |
| -124.4541 | -124.3369 | -124.2197 | -124.1025 | -123.9854 | -123.8682 |
| -123.751  | -123.6338 | -123.5166 | -123.3994 | -123.2822 | -123.165  |
| -123.0479 | -122.9307 | -122.8135 | -122.6963 | -122.5791 | -122.4619 |
| -122.3447 | -122.2275 | -122.1104 | -121.9932 | -121.876  | -121.7589 |
| -121.6417 | -121.5245 | -121.4073 | -121.2901 | -121.1729 | -121.0557 |
| -120.9385 | -120.8214 | -120.7042 | -120.587  | -120.4698 | -120.3526 |
| -120.2354 | -120.1182 | -120.001  | -119.8839 | -119.7667 | -119.6495 |
| -119.5323 | -119.4151 | -119.2979 | -119.1807 | -119.0635 | -118.9464 |
| -118.8292 | -118.712  | -118.5948 | -118.4776 | -118.3604 | -118.2432 |

Table 12: Gaussian T1534 acceptable longitude values (continued)

|           |           |           |           |           |           |
|-----------|-----------|-----------|-----------|-----------|-----------|
| -118.126  | -118.0089 | -117.8917 | -117.7745 | -117.6573 | -117.5401 |
| -117.4229 | -117.3057 | -117.1885 | -117.0714 | -116.9542 | -116.837  |
| -116.7198 | -116.6026 | -116.4854 | -116.3682 | -116.251  | -116.1339 |
| -116.0167 | -115.8995 | -115.7823 | -115.6651 | -115.5479 | -115.4307 |
| -115.3135 | -115.1964 | -115.0792 | -114.962  | -114.8448 | -114.7276 |
| -114.6104 | -114.4932 | -114.376  | -114.2589 | -114.1417 | -114.0245 |
| -113.9073 | -113.7901 | -113.6729 | -113.5557 | -113.4385 | -113.3214 |
| -113.2042 | -113.087  | -112.9698 | -112.8526 | -112.7354 | -112.6182 |
| -112.501  | -112.3839 | -112.2667 | -112.1495 | -112.0323 | -111.9151 |
| -111.7979 | -111.6807 | -111.5635 | -111.4464 | -111.3292 | -111.212  |
| -111.0948 | -110.9777 | -110.8605 | -110.7433 | -110.6261 | -110.5089 |
| -110.3917 | -110.2745 | -110.1573 | -110.0402 | -109.923  | -109.8058 |
| -109.6886 | -109.5714 | -109.4542 | -109.337  | -109.2198 | -109.1027 |
| -108.9855 | -108.8683 | -108.7511 | -108.6339 | -108.5167 | -108.3995 |
| -108.2823 | -108.1652 | -108.048  | -107.9308 | -107.8136 | -107.6964 |
| -107.5792 | -107.462  | -107.3448 | -107.2277 | -107.1105 | -106.9933 |
| -106.8761 | -106.7589 | -106.6417 | -106.5245 | -106.4073 | -106.2902 |
| -106.173  | -106.0558 | -105.9386 | -105.8214 | -105.7042 | -105.587  |
| -105.4698 | -105.3527 | -105.2355 | -105.1183 | -105.0011 | -104.8839 |
| -104.7667 | -104.6495 | -104.5323 | -104.4152 | -104.298  | -104.1808 |
| -104.0636 | -103.9464 | -103.8292 | -103.712  | -103.5948 | -103.4777 |
| -103.3605 | -103.2433 | -103.1261 | -103.0089 | -102.8917 | -102.7745 |
| -102.6573 | -102.5402 | -102.423  | -102.3058 | -102.1886 | -102.0714 |
| -101.9542 | -101.837  | -101.7198 | -101.6027 | -101.4855 | -101.3683 |
| -101.2511 | -101.1339 | -101.0167 | -100.8995 | -100.7823 | -100.6652 |
| -100.548  | -100.4308 | -100.3136 | -100.1964 | -100.0792 | -99.96204 |
| -99.84485 | -99.72766 | -99.61047 | -99.49329 | -99.3761  | -99.25891 |
| -99.14172 | -99.02454 | -98.90735 | -98.79016 | -98.67297 | -98.55579 |
| -98.4386  | -98.32141 | -98.20422 | -98.08704 | -97.96985 | -97.85266 |
| -97.73547 | -97.61829 | -97.5011  | -97.38391 | -97.26672 | -97.14954 |
| -97.03235 | -96.91516 | -96.79797 | -96.68079 | -96.5636  | -96.44641 |
| -96.32922 | -96.21204 | -96.09485 | -95.97766 | -95.86047 | -95.74329 |
| -95.6261  | -95.50891 | -95.39172 | -95.27454 | -95.15735 | -95.04016 |
| -94.92297 | -94.80579 | -94.6886  | -94.57141 | -94.45422 | -94.33704 |
| -94.21985 | -94.10266 | -93.98547 | -93.86829 | -93.7511  | -93.63391 |
| -93.51672 | -93.39954 | -93.28235 | -93.16516 | -93.04797 | -92.93079 |
| -92.8136  | -92.69641 | -92.57922 | -92.46204 | -92.34485 | -92.22766 |
| -92.11047 | -91.99329 | -91.8761  | -91.75891 | -91.64172 | -91.52454 |
| -91.40735 | -91.29022 | -91.17303 | -91.05585 | -90.93866 | -90.82147 |
| -90.70428 | -90.5871  | -90.46991 | -90.35272 | -90.23553 | -90.11835 |
| -90.00116 | -89.88397 | -89.76678 | -89.6496  | -89.53241 | -89.41522 |
| -89.29803 | -89.18085 | -89.06366 | -88.94647 | -88.82928 | -88.7121  |
| -88.59491 | -88.47772 | -88.36053 | -88.24335 | -88.12616 | -88.00897 |

Table 13: Gaussian T1534 acceptable longitude values (continued)

|           |           |           |           |           |           |
|-----------|-----------|-----------|-----------|-----------|-----------|
| -87.89178 | -87.7746  | -87.65741 | -87.54022 | -87.42303 | -87.30585 |
| -87.18866 | -87.07147 | -86.95428 | -86.8371  | -86.71991 | -86.60272 |
| -86.48553 | -86.36835 | -86.25116 | -86.13397 | -86.01678 | -85.8996  |
| -85.78241 | -85.66522 | -85.54803 | -85.43085 | -85.31366 | -85.19647 |
| -85.07928 | -84.9621  | -84.84491 | -84.72772 | -84.61053 | -84.49335 |
| -84.37616 | -84.25897 | -84.14185 | -84.02466 | -83.90747 | -83.79028 |
| -83.6731  | -83.55591 | -83.43872 | -83.32153 | -83.20435 | -83.08716 |
| -82.96997 | -82.85278 | -82.7356  | -82.61841 | -82.50122 | -82.38403 |
| -82.26685 | -82.14966 | -82.03247 | -81.91528 | -81.7981  | -81.68091 |
| -81.56372 | -81.44653 | -81.32935 | -81.21216 | -81.09497 | -80.97778 |
| -80.8606  | -80.74341 | -80.62622 | -80.50903 | -80.39185 | -80.27466 |
| -80.15747 | -80.04028 | -79.9231  | -79.80591 | -79.68872 | -79.57153 |
| -79.45435 | -79.33716 | -79.21997 | -79.10278 | -78.9856  | -78.86841 |
| -78.75122 | -78.63403 | -78.51685 | -78.39966 | -78.28247 | -78.16528 |
| -78.0481  | -77.93091 | -77.81372 | -77.69653 | -77.57935 | -77.46216 |
| -77.34497 | -77.22778 | -77.1106  | -76.99341 | -76.87622 | -76.75903 |
| -76.64185 | -76.52466 | -76.40747 | -76.29028 | -76.1731  | -76.05591 |
| -75.93872 | -75.82153 | -75.70435 | -75.58716 | -75.46997 | -75.35278 |
| -75.2356  | -75.11841 | -75.00122 | -74.88403 | -74.76685 | -74.64966 |
| -74.53247 | -74.41528 | -74.2981  | -74.18091 | -74.06372 | -73.94653 |
| -73.82935 | -73.71216 | -73.59497 | -73.47778 | -73.3606  | -73.24341 |
| -73.12622 | -73.00903 | -72.89185 | -72.77466 | -72.65747 | -72.54028 |
| -72.4231  | -72.30591 | -72.18872 | -72.07153 | -71.95435 | -71.83716 |
| -71.71997 | -71.60278 | -71.4856  | -71.36841 | -71.25122 | -71.13403 |
| -71.01685 | -70.89966 | -70.78247 | -70.66528 | -70.5481  | -70.43091 |
| -70.31372 | -70.19653 | -70.07935 | -69.96216 | -69.84497 | -69.72778 |
| -69.6106  | -69.49341 | -69.37622 | -69.25903 | -69.14185 | -69.02466 |
| -68.90747 | -68.79028 | -68.6731  | -68.55591 | -68.43872 | -68.32153 |
| -68.20435 | -68.08716 | -67.96997 | -67.85278 | -67.7356  | -67.61841 |
| -67.50122 | -67.38403 | -67.26685 | -67.14966 | -67.03247 | -66.91528 |
| -66.7981  | -66.68091 | -66.56372 | -66.44653 | -66.32935 | -66.21216 |
| -66.09497 | -65.97778 | -65.8606  | -65.74341 | -65.62622 | -65.50903 |
| -65.39185 | -65.27466 | -65.15747 | -65.04028 | -64.9231  | -64.80591 |
| -64.68872 | -64.57153 | -64.45435 | -64.33716 | -64.21997 | -64.10278 |
| -63.9856  | -63.86841 | -63.75122 | -63.63403 | -63.51685 | -63.39966 |
| -63.28247 | -63.16528 | -63.0481  | -62.93091 | -62.81372 | -62.69653 |
| -62.57941 | -62.46222 | -62.34503 | -62.22784 | -62.11066 | -61.99347 |
| -61.87628 | -61.75909 | -61.64191 | -61.52472 | -61.40753 | -61.29034 |
| -61.17316 | -61.05597 | -60.93878 | -60.82159 | -60.70441 | -60.58722 |
| -60.47003 | -60.35284 | -60.23566 | -60.11847 | -60.00128 | -59.88409 |
| -59.76691 | -59.64972 | -59.53253 | -59.41534 | -59.29816 | -59.18097 |
| -59.06378 | -58.94659 | -58.82941 | -58.71222 | -58.59503 | -58.47784 |
| -58.36066 | -58.24347 | -58.12628 | -58.00909 | -57.89191 | -57.77472 |

Table 14: Gaussian T1534 acceptable longitude values (continued)

|           |           |           |           |           |           |
|-----------|-----------|-----------|-----------|-----------|-----------|
| -57.65753 | -57.54034 | -57.42316 | -57.30597 | -57.18878 | -57.07159 |
| -56.95441 | -56.83722 | -56.72003 | -56.60284 | -56.48566 | -56.36847 |
| -56.25128 | -56.13409 | -56.01691 | -55.89972 | -55.78253 | -55.66534 |
| -55.54816 | -55.43103 | -55.31384 | -55.19666 | -55.07947 | -54.96228 |
| -54.84509 | -54.72791 | -54.61072 | -54.49353 | -54.37634 | -54.25916 |
| -54.14197 | -54.02478 | -53.90759 | -53.79041 | -53.67322 | -53.55603 |
| -53.43884 | -53.32166 | -53.20447 | -53.08728 | -52.97009 | -52.85291 |
| -52.73572 | -52.61853 | -52.50134 | -52.38416 | -52.26697 | -52.14978 |
| -52.03259 | -51.91541 | -51.79822 | -51.68103 | -51.56384 | -51.44666 |
| -51.32947 | -51.21228 | -51.09509 | -50.97791 | -50.86072 | -50.74353 |
| -50.62634 | -50.50916 | -50.39197 | -50.27478 | -50.15759 | -50.04041 |
| -49.92322 | -49.80603 | -49.68884 | -49.57166 | -49.45447 | -49.33728 |
| -49.22009 | -49.10291 | -48.98572 | -48.86853 | -48.75134 | -48.63416 |
| -48.51697 | -48.39978 | -48.28259 | -48.16541 | -48.04822 | -47.93103 |
| -47.81384 | -47.69666 | -47.57947 | -47.46228 | -47.34509 | -47.22791 |
| -47.11072 | -46.99353 | -46.87634 | -46.75916 | -46.64197 | -46.52478 |
| -46.40759 | -46.29041 | -46.17322 | -46.05603 | -45.93884 | -45.82166 |
| -45.70447 | -45.58728 | -45.47009 | -45.35291 | -45.23572 | -45.11853 |
| -45.00134 | -44.88416 | -44.76697 | -44.64978 | -44.53259 | -44.41541 |
| -44.29822 | -44.18103 | -44.06384 | -43.94666 | -43.82947 | -43.71228 |
| -43.59509 | -43.47791 | -43.36072 | -43.24353 | -43.12634 | -43.00916 |
| -42.89197 | -42.77478 | -42.65759 | -42.54041 | -42.42322 | -42.30603 |
| -42.18884 | -42.07166 | -41.95447 | -41.83728 | -41.72009 | -41.60291 |
| -41.48572 | -41.36853 | -41.25134 | -41.13416 | -41.01697 | -40.89978 |
| -40.78259 | -40.66541 | -40.54822 | -40.43103 | -40.31384 | -40.19666 |
| -40.07947 | -39.96228 | -39.84509 | -39.72791 | -39.61072 | -39.49353 |
| -39.37634 | -39.25916 | -39.14197 | -39.02478 | -38.90759 | -38.79041 |
| -38.67322 | -38.55603 | -38.43884 | -38.32166 | -38.20447 | -38.08728 |
| -37.97009 | -37.85291 | -37.73572 | -37.61853 | -37.50134 | -37.38416 |
| -37.26697 | -37.14978 | -37.03259 | -36.91541 | -36.79822 | -36.68103 |
| -36.56384 | -36.44666 | -36.32947 | -36.21228 | -36.09509 | -35.97791 |
| -35.86072 | -35.74353 | -35.62634 | -35.50916 | -35.39197 | -35.27478 |
| -35.15759 | -35.04041 | -34.92322 | -34.80603 | -34.68884 | -34.57166 |
| -34.45447 | -34.33728 | -34.22009 | -34.10291 | -33.98578 | -33.86859 |
| -33.7514  | -33.63422 | -33.51703 | -33.39984 | -33.28265 | -33.16547 |
| -33.04828 | -32.93109 | -32.8139  | -32.69672 | -32.57953 | -32.46234 |
| -32.34515 | -32.22797 | -32.11078 | -31.99359 | -31.8764  | -31.75922 |
| -31.64203 | -31.52484 | -31.40765 | -31.29047 | -31.17328 | -31.05609 |
| -30.9389  | -30.82172 | -30.70453 | -30.58734 | -30.47015 | -30.35297 |
| -30.23578 | -30.11859 | -30.0014  | -29.88422 | -29.76703 | -29.64984 |
| -29.53265 | -29.41547 | -29.29828 | -29.18109 | -29.0639  | -28.94672 |
| -28.82953 | -28.71234 | -28.59515 | -28.47797 | -28.36078 | -28.24359 |
| -28.1264  | -28.00922 | -27.89203 | -27.77484 | -27.65765 | -27.54047 |

Table 15: Gaussian T1534 acceptable longitude values (continued)

|            |            |            |            |            |            |
|------------|------------|------------|------------|------------|------------|
| -27.42328  | -27.30609  | -27.1889   | -27.07172  | -26.95453  | -26.8374   |
| -26.72021  | -26.60303  | -26.48584  | -26.36865  | -26.25146  | -26.13428  |
| -26.01709  | -25.8999   | -25.78271  | -25.66553  | -25.54834  | -25.43115  |
| -25.31396  | -25.19678  | -25.07959  | -24.9624   | -24.84521  | -24.72803  |
| -24.61084  | -24.49365  | -24.37646  | -24.25928  | -24.14209  | -24.0249   |
| -23.90771  | -23.79053  | -23.67334  | -23.55615  | -23.43896  | -23.32178  |
| -23.20459  | -23.0874   | -22.97021  | -22.85303  | -22.73584  | -22.61865  |
| -22.50146  | -22.38428  | -22.26709  | -22.1499   | -22.03271  | -21.91553  |
| -21.79834  | -21.68115  | -21.56396  | -21.44678  | -21.32959  | -21.2124   |
| -21.09521  | -20.97803  | -20.86084  | -20.74365  | -20.62646  | -20.50928  |
| -20.39209  | -20.2749   | -20.15771  | -20.04053  | -19.92334  | -19.80615  |
| -19.68896  | -19.57178  | -19.45459  | -19.3374   | -19.22021  | -19.10303  |
| -18.98584  | -18.86865  | -18.75146  | -18.63428  | -18.51709  | -18.3999   |
| -18.28271  | -18.16553  | -18.04834  | -17.93115  | -17.81396  | -17.69678  |
| -17.57959  | -17.4624   | -17.34521  | -17.22803  | -17.11084  | -16.99365  |
| -16.87646  | -16.75928  | -16.64209  | -16.5249   | -16.40771  | -16.29053  |
| -16.17334  | -16.05615  | -15.93896  | -15.82178  | -15.70459  | -15.5874   |
| -15.47021  | -15.35303  | -15.23584  | -15.11865  | -15.00146  | -14.88428  |
| -14.76709  | -14.6499   | -14.53271  | -14.41553  | -14.29834  | -14.18115  |
| -14.06396  | -13.94678  | -13.82959  | -13.7124   | -13.59521  | -13.47803  |
| -13.36084  | -13.24365  | -13.12646  | -13.00928  | -12.89209  | -12.7749   |
| -12.65771  | -12.54053  | -12.42334  | -12.30615  | -12.18896  | -12.07178  |
| -11.95459  | -11.8374   | -11.72021  | -11.60303  | -11.48584  | -11.36865  |
| -11.25146  | -11.13428  | -11.01709  | -10.8999   | -10.78271  | -10.66553  |
| -10.54834  | -10.43115  | -10.31396  | -10.19678  | -10.07959  | -9.962402  |
| -9.845215  | -9.728027  | -9.61084   | -9.493652  | -9.376465  | -9.259277  |
| -9.14209   | -9.024902  | -8.907715  | -8.790527  | -8.67334   | -8.556152  |
| -8.438965  | -8.321777  | -8.20459   | -8.087402  | -7.970215  | -7.853027  |
| -7.73584   | -7.618652  | -7.501465  | -7.384277  | -7.26709   | -7.149902  |
| -7.032715  | -6.915527  | -6.79834   | -6.681152  | -6.563965  | -6.446777  |
| -6.32959   | -6.212402  | -6.095215  | -5.978027  | -5.86084   | -5.743652  |
| -5.626465  | -5.509277  | -5.39209   | -5.274963  | -5.157776  | -5.040588  |
| -4.923401  | -4.806213  | -4.689026  | -4.571838  | -4.454651  | -4.337463  |
| -4.220276  | -4.103088  | -3.985901  | -3.868713  | -3.751526  | -3.634338  |
| -3.517151  | -3.399963  | -3.282776  | -3.165588  | -3.048401  | -2.931213  |
| -2.814026  | -2.696838  | -2.579651  | -2.462463  | -2.345276  | -2.228088  |
| -2.110901  | -1.993713  | -1.876526  | -1.759338  | -1.642151  | -1.524963  |
| -1.407776  | -1.290588  | -1.173401  | -1.056213  | -0.9390259 | -0.8218384 |
| -0.7046509 | -0.5874634 | -0.4702759 | -0.3530884 | -0.2359009 | -0.1187134 |

Table 16: Gaussian T1534 acceptable latitude values

|           |           |           |           |           |           |
|-----------|-----------|-----------|-----------|-----------|-----------|
| -89.90934 | -89.79441 | -89.67735 | -89.56031 | -89.44327 | -89.32623 |
| -89.20895 | -89.09194 | -88.97473 | -88.85756 | -88.74057 | -88.62342 |
| -88.50629 | -88.38905 | -88.27195 | -88.15485 | -88.03766 | -87.92048 |
| -87.8034  | -87.68624 | -87.56908 | -87.45193 | -87.33479 | -87.21764 |
| -87.10051 | -86.98331 | -86.86618 | -86.74905 | -86.63193 | -86.51473 |
| -86.39761 | -86.28048 | -86.16329 | -86.04616 | -85.92902 | -85.81188 |
| -85.6947  | -85.57755 | -85.46041 | -85.34326 | -85.2261  | -85.10899 |
| -84.99183 | -84.87466 | -84.75753 | -84.64039 | -84.52324 | -84.40609 |
| -84.28893 | -84.17179 | -84.05462 | -83.93748 | -83.82035 | -83.70319 |
| -83.58604 | -83.46889 | -83.35176 | -83.23459 | -83.11744 | -83.0003  |
| -82.88316 | -82.766   | -82.64886 | -82.53171 | -82.41454 | -82.29739 |
| -82.18025 | -82.06311 | -81.94596 | -81.82881 | -81.71165 | -81.59451 |
| -81.47736 | -81.36021 | -81.24307 | -81.12591 | -81.00877 | -80.89161 |
| -80.77446 | -80.65731 | -80.54017 | -80.42301 | -80.30588 | -80.18873 |
| -80.07158 | -79.95442 | -79.83728 | -79.72014 | -79.60297 | -79.48582 |
| -79.36868 | -79.25153 | -79.13438 | -79.01723 | -78.90009 | -78.78293 |
| -78.66579 | -78.54864 | -78.43148 | -78.31432 | -78.19718 | -78.08003 |
| -77.96289 | -77.84574 | -77.72859 | -77.61144 | -77.49429 | -77.37714 |
| -77.25999 | -77.14284 | -77.0257  | -76.90854 | -76.79139 | -76.67425 |
| -76.5571  | -76.43994 | -76.32279 | -76.20565 | -76.0885  | -75.97136 |
| -75.8542  | -75.73705 | -75.6199  | -75.50275 | -75.3856  | -75.26846 |
| -75.15131 | -75.03416 | -74.91701 | -74.79985 | -74.6827  | -74.56556 |
| -74.44841 | -74.33126 | -74.21411 | -74.09696 | -73.97981 | -73.86266 |
| -73.74551 | -73.62836 | -73.51122 | -73.39407 | -73.27691 | -73.15977 |
| -73.04262 | -72.92546 | -72.80832 | -72.69117 | -72.57402 | -72.45686 |
| -72.33972 | -72.22257 | -72.10542 | -71.98827 | -71.87112 | -71.75397 |
| -71.63682 | -71.51968 | -71.40253 | -71.28537 | -71.16824 | -71.05108 |
| -70.93392 | -70.81679 | -70.69963 | -70.58248 | -70.46534 | -70.34818 |
| -70.23103 | -70.11389 | -69.99673 | -69.87959 | -69.76244 | -69.64529 |
| -69.52814 | -69.41099 | -69.29384 | -69.17669 | -69.05954 | -68.9424  |
| -68.82524 | -68.70809 | -68.59094 | -68.4738  | -68.35664 | -68.23949 |
| -68.12234 | -68.0052  | -67.88805 | -67.7709  | -67.65375 | -67.5366  |
| -67.41945 | -67.3023  | -67.18515 | -67.06799 | -66.95085 | -66.83371 |
| -66.71655 | -66.59941 | -66.48226 | -66.3651  | -66.24796 | -66.13081 |
| -66.01366 | -65.89651 | -65.77936 | -65.66222 | -65.54506 | -65.42791 |
| -65.31077 | -65.19361 | -65.07647 | -64.95931 | -64.84216 | -64.72501 |
| -64.60786 | -64.49072 | -64.37356 | -64.25642 | -64.13927 | -64.02212 |
| -63.90497 | -63.78783 | -63.67067 | -63.55352 | -63.43637 | -63.31922 |
| -63.20208 | -63.08492 | -62.96778 | -62.85063 | -62.73347 | -62.61633 |
| -62.49918 | -62.38203 | -62.26488 | -62.14773 | -62.03058 | -61.91343 |
| -61.79628 | -61.67913 | -61.56199 | -61.44483 | -61.32769 | -61.21053 |
| -61.09339 | -60.97623 | -60.85909 | -60.74194 | -60.62479 | -60.50764 |

Table 17: Gaussian T1534 acceptable latitude values (continued)

|           |           |           |           |           |           |
|-----------|-----------|-----------|-----------|-----------|-----------|
| -60.39049 | -60.27335 | -60.15619 | -60.03904 | -59.9219  | -59.80474 |
| -59.6876  | -59.57044 | -59.4533  | -59.33615 | -59.219   | -59.10184 |
| -58.9847  | -58.86755 | -58.7504  | -58.63325 | -58.5161  | -58.39895 |
| -58.2818  | -58.16465 | -58.04751 | -57.93036 | -57.81321 | -57.69605 |
| -57.57891 | -57.46176 | -57.34461 | -57.22746 | -57.11031 | -56.99316 |
| -56.87601 | -56.75886 | -56.64171 | -56.52456 | -56.40741 | -56.29026 |
| -56.17311 | -56.05597 | -55.93881 | -55.82167 | -55.70452 | -55.58737 |
| -55.47022 | -55.35307 | -55.23592 | -55.11877 | -55.00162 | -54.88447 |
| -54.76732 | -54.65018 | -54.53302 | -54.41588 | -54.29873 | -54.18158 |
| -54.06443 | -53.94728 | -53.83013 | -53.71298 | -53.59583 | -53.47868 |
| -53.36153 | -53.24438 | -53.12724 | -53.01008 | -52.89294 | -52.77578 |
| -52.65863 | -52.54148 | -52.42433 | -52.30719 | -52.19003 | -52.07289 |
| -51.95574 | -51.83859 | -51.72144 | -51.60429 | -51.48714 | -51.36999 |
| -51.25284 | -51.13569 | -51.01854 | -50.9014  | -50.78424 | -50.6671  |
| -50.54995 | -50.4328  | -50.31565 | -50.1985  | -50.08135 | -49.9642  |
| -49.84705 | -49.7299  | -49.61275 | -49.4956  | -49.37845 | -49.2613  |
| -49.14416 | -49.027   | -48.90985 | -48.79271 | -48.67556 | -48.55841 |
| -48.44126 | -48.3241  | -48.20696 | -48.08981 | -47.97266 | -47.85551 |
| -47.73836 | -47.62122 | -47.50406 | -47.38691 | -47.26976 | -47.15261 |
| -47.03547 | -46.91831 | -46.80117 | -46.68402 | -46.56687 | -46.44972 |
| -46.33257 | -46.21542 | -46.09827 | -45.98112 | -45.86397 | -45.74682 |
| -45.62967 | -45.51252 | -45.39537 | -45.27822 | -45.16108 | -45.04393 |
| -44.92678 | -44.80963 | -44.69248 | -44.57533 | -44.45818 | -44.34103 |
| -44.22388 | -44.10673 | -43.98958 | -43.87244 | -43.75528 | -43.63813 |
| -43.52098 | -43.40384 | -43.28669 | -43.16954 | -43.05238 | -42.93524 |
| -42.81809 | -42.70094 | -42.58379 | -42.46664 | -42.34949 | -42.23234 |
| -42.1152  | -41.99804 | -41.88089 | -41.76374 | -41.6466  | -41.52945 |
| -41.4123  | -41.29514 | -41.178   | -41.06085 | -40.9437  | -40.82655 |
| -40.7094  | -40.59225 | -40.4751  | -40.35796 | -40.2408  | -40.12365 |
| -40.00651 | -39.88935 | -39.77221 | -39.65506 | -39.53791 | -39.42076 |
| -39.30361 | -39.18646 | -39.06931 | -38.95216 | -38.83501 | -38.71786 |
| -38.60072 | -38.48357 | -38.36641 | -38.24926 | -38.13211 | -38.01497 |
| -37.89782 | -37.78067 | -37.66352 | -37.54637 | -37.42922 | -37.31207 |
| -37.19492 | -37.07777 | -36.96062 | -36.84347 | -36.72632 | -36.60917 |
| -36.49202 | -36.37487 | -36.25772 | -36.14058 | -36.02342 | -35.90628 |
| -35.78913 | -35.67198 | -35.55483 | -35.43768 | -35.32053 | -35.20338 |
| -35.08624 | -34.96909 | -34.85193 | -34.73479 | -34.61763 | -34.50048 |
| -34.38334 | -34.26618 | -34.14904 | -34.03189 | -33.91474 | -33.79759 |
| -33.68044 | -33.56329 | -33.44614 | -33.32899 | -33.21184 | -33.09469 |
| -32.97754 | -32.86039 | -32.74324 | -32.62609 | -32.50895 | -32.3918  |
| -32.27465 | -32.1575  | -32.04035 | -31.9232  | -31.80605 | -31.6889  |
| -31.57175 | -31.4546  | -31.33745 | -31.2203  | -31.10315 | -30.986   |

Table 18: Gaussian T1534 acceptable latitude values (continued)

|            |            |            |            |            |             |
|------------|------------|------------|------------|------------|-------------|
| -30.86885  | -30.75171  | -30.63456  | -30.5174   | -30.40026  | -30.28311   |
| -30.16596  | -30.04881  | -29.93166  | -29.81451  | -29.69736  | -29.58021   |
| -29.46307  | -29.34591  | -29.22877  | -29.11161  | -28.99447  | -28.87732   |
| -28.76017  | -28.64302  | -28.52587  | -28.40872  | -28.29157  | -28.17442   |
| -28.05727  | -27.94012  | -27.82297  | -27.70582  | -27.58867  | -27.47153   |
| -27.35438  | -27.23722  | -27.12008  | -27.00293  | -26.88578  | -26.76863   |
| -26.65148  | -26.53433  | -26.41718  | -26.30003  | -26.18288  | -26.06573   |
| -25.94858  | -25.83143  | -25.71428  | -25.59714  | -25.47998  | -25.36283   |
| -25.24569  | -25.12854  | -25.01139  | -24.89424  | -24.77709  | -24.65994   |
| -24.54279  | -24.42564  | -24.30849  | -24.19134  | -24.07419  | -23.95704   |
| -23.8399   | -23.72274  | -23.60559  | -23.48845  | -23.3713   | -23.25415   |
| -23.137    | -23.01985  | -22.9027   | -22.78555  | -22.6684   | -22.55125   |
| -22.4341   | -22.31695  | -22.1998   | -22.08265  | -21.96551  | -21.84836   |
| -21.7312   | -21.61406  | -21.49691  | -21.37976  | -21.26261  | -21.14546   |
| -21.02831  | -20.91116  | -20.79401  | -20.67686  | -20.55971  | -20.44256   |
| -20.32541  | -20.20826  | -20.09111  | -19.97396  | -19.85681  | -19.73967   |
| -19.62252  | -19.50537  | -19.38822  | -19.27107  | -19.15392  | -19.03677   |
| -18.91962  | -18.80247  | -18.68532  | -18.56817  | -18.45103  | -18.33388   |
| -18.21672  | -18.09958  | -17.98243  | -17.86528  | -17.74813  | -17.63098   |
| -17.51383  | -17.39668  | -17.27953  | -17.16238  | -17.04523  | -16.92808   |
| -16.81093  | -16.69378  | -16.57664  | -16.45948  | -16.34233  | -16.22519   |
| -16.10804  | -15.99089  | -15.87374  | -15.75659  | -15.63944  | -15.52229   |
| -15.40514  | -15.28799  | -15.17084  | -15.05369  | -14.93654  | -14.81939   |
| -14.70224  | -14.5851   | -14.46795  | -14.3508   | -14.23365  | -14.1165    |
| -13.99935  | -13.8822   | -13.76505  | -13.6479   | -13.53075  | -13.4136    |
| -13.29645  | -13.1793   | -13.06215  | -12.945    | -12.82786  | -12.7107    |
| -12.59356  | -12.47641  | -12.35926  | -12.24211  | -12.12496  | -12.00781   |
| -11.89066  | -11.77351  | -11.65636  | -11.53921  | -11.42206  | -11.30491   |
| -11.18776  | -11.07061  | -10.95346  | -10.83632  | -10.71917  | -10.60202   |
| -10.48487  | -10.36772  | -10.25057  | -10.13342  | -10.01627  | -9.89912    |
| -9.781971  | -9.664822  | -9.547672  | -9.430523  | -9.313374  | -9.196224   |
| -9.079076  | -8.961926  | -8.844776  | -8.727627  | -8.610477  | -8.493328   |
| -8.376179  | -8.259029  | -8.14188   | -8.024731  | -7.907581  | -7.790431   |
| -7.673283  | -7.556134  | -7.438984  | -7.321835  | -7.204686  | -7.087536   |
| -6.970387  | -6.853238  | -6.736088  | -6.618938  | -6.501789  | -6.38464    |
| -6.267491  | -6.150342  | -6.033192  | -5.916042  | -5.798893  | -5.681744   |
| -5.564595  | -5.447445  | -5.330295  | -5.213146  | -5.095997  | -4.978848   |
| -4.861699  | -4.744549  | -4.627399  | -4.51025   | -4.393101  | -4.275951   |
| -4.158802  | -4.041653  | -3.924504  | -3.807354  | -3.690205  | -3.573056   |
| -3.455906  | -3.338757  | -3.221607  | -3.104458  | -2.987309  | -2.870159   |
| -2.75301   | -2.635861  | -2.518711  | -2.401562  | -2.284412  | -2.167263   |
| -2.050114  | -1.932964  | -1.815815  | -1.698666  | -1.581516  | -1.464367   |
| -1.347218  | -1.230068  | -1.112919  | -0.9957695 | -0.8786201 | -0.7614708  |
| -0.6443214 | -0.5271721 | -0.4100228 | -0.2928734 | -0.175724  | -0.05857468 |

Table 19: Gaussian T1534 acceptable latitude values (continued)

|            |           |           |           |           |           |
|------------|-----------|-----------|-----------|-----------|-----------|
| 0.05857468 | 0.175724  | 0.2928734 | 0.4100228 | 0.5271721 | 0.6443214 |
| 0.7614708  | 0.8786201 | 0.9957695 | 1.112919  | 1.230068  | 1.347218  |
| 1.464367   | 1.581516  | 1.698666  | 1.815815  | 1.932964  | 2.050114  |
| 2.167263   | 2.284412  | 2.401562  | 2.518711  | 2.635861  | 2.75301   |
| 2.870159   | 2.987309  | 3.104458  | 3.221607  | 3.338757  | 3.455906  |
| 3.573056   | 3.690205  | 3.807354  | 3.924504  | 4.041653  | 4.158802  |
| 4.275951   | 4.393101  | 4.51025   | 4.627399  | 4.744549  | 4.861699  |
| 4.978848   | 5.095997  | 5.213146  | 5.330295  | 5.447445  | 5.564595  |
| 5.681744   | 5.798893  | 5.916042  | 6.033192  | 6.150342  | 6.267491  |
| 6.38464    | 6.501789  | 6.618938  | 6.736088  | 6.853238  | 6.970387  |
| 7.087536   | 7.204686  | 7.321835  | 7.438984  | 7.556134  | 7.673283  |
| 7.790431   | 7.907581  | 8.024731  | 8.14188   | 8.259029  | 8.376179  |
| 8.493328   | 8.610477  | 8.727627  | 8.844776  | 8.961926  | 9.079076  |
| 9.196224   | 9.313374  | 9.430523  | 9.547672  | 9.664822  | 9.781971  |
| 9.89912    | 10.01627  | 10.13342  | 10.25057  | 10.36772  | 10.48487  |
| 10.60202   | 10.71917  | 10.83632  | 10.95346  | 11.07061  | 11.18776  |
| 11.30491   | 11.42206  | 11.53921  | 11.65636  | 11.77351  | 11.89066  |
| 12.00781   | 12.12496  | 12.24211  | 12.35926  | 12.47641  | 12.59356  |
| 12.7107    | 12.82786  | 12.945    | 13.06215  | 13.1793   | 13.29645  |
| 13.4136    | 13.53075  | 13.6479   | 13.76505  | 13.8822   | 13.99935  |
| 14.1165    | 14.23365  | 14.3508   | 14.46795  | 14.5851   | 14.70224  |
| 14.81939   | 14.93654  | 15.05369  | 15.17084  | 15.28799  | 15.40514  |
| 15.52229   | 15.63944  | 15.75659  | 15.87374  | 15.99089  | 16.10804  |
| 16.22519   | 16.34233  | 16.45948  | 16.57664  | 16.69378  | 16.81093  |
| 16.92808   | 17.04523  | 17.16238  | 17.27953  | 17.39668  | 17.51383  |
| 17.63098   | 17.74813  | 17.86528  | 17.98243  | 18.09958  | 18.21672  |
| 18.33388   | 18.45103  | 18.56817  | 18.68532  | 18.80247  | 18.91962  |
| 19.03677   | 19.15392  | 19.27107  | 19.38822  | 19.50537  | 19.62252  |
| 19.73967   | 19.85681  | 19.97396  | 20.09111  | 20.20826  | 20.32541  |
| 20.44256   | 20.55971  | 20.67686  | 20.79401  | 20.91116  | 21.02831  |
| 21.14546   | 21.26261  | 21.37976  | 21.49691  | 21.61406  | 21.7312   |
| 21.84836   | 21.96551  | 22.08265  | 22.1998   | 22.31695  | 22.4341   |
| 22.55125   | 22.6684   | 22.78555  | 22.9027   | 23.01985  | 23.137    |
| 23.25415   | 23.3713   | 23.48845  | 23.60559  | 23.72274  | 23.8399   |
| 23.95704   | 24.07419  | 24.19134  | 24.30849  | 24.42564  | 24.54279  |
| 24.65994   | 24.77709  | 24.89424  | 25.01139  | 25.12854  | 25.24569  |
| 25.36283   | 25.47998  | 25.59714  | 25.71428  | 25.83143  | 25.94858  |
| 26.06573   | 26.18288  | 26.30003  | 26.41718  | 26.53433  | 26.65148  |
| 26.76863   | 26.88578  | 27.00293  | 27.12008  | 27.23722  | 27.35438  |
| 27.47153   | 27.58867  | 27.70582  | 27.82297  | 27.94012  | 28.05727  |
| 28.17442   | 28.29157  | 28.40872  | 28.52587  | 28.64302  | 28.76017  |
| 28.87732   | 28.99447  | 29.11161  | 29.22877  | 29.34591  | 29.46307  |
| 29.58021   | 29.69736  | 29.81451  | 29.93166  | 30.04881  | 30.16596  |
| 30.28311   | 30.40026  | 30.5174   | 30.63456  | 30.75171  | 30.86885  |

Table 20: Gaussian T1534 acceptable latitude values (continued)

|          |          |          |          |          |          |
|----------|----------|----------|----------|----------|----------|
| 30.986   | 31.10315 | 31.2203  | 31.33745 | 31.4546  | 31.57175 |
| 31.6889  | 31.80605 | 31.9232  | 32.04035 | 32.1575  | 32.27465 |
| 32.3918  | 32.50895 | 32.62609 | 32.74324 | 32.86039 | 32.97754 |
| 33.09469 | 33.21184 | 33.32899 | 33.44614 | 33.56329 | 33.68044 |
| 33.79759 | 33.91474 | 34.03189 | 34.14904 | 34.26618 | 34.38334 |
| 34.50048 | 34.61763 | 34.73479 | 34.85193 | 34.96909 | 35.08624 |
| 35.20338 | 35.32053 | 35.43768 | 35.55483 | 35.67198 | 35.78913 |
| 35.90628 | 36.02342 | 36.14058 | 36.25772 | 36.37487 | 36.49202 |
| 36.60917 | 36.72632 | 36.84347 | 36.96062 | 37.07777 | 37.19492 |
| 37.31207 | 37.42922 | 37.54637 | 37.66352 | 37.78067 | 37.89782 |
| 38.01497 | 38.13211 | 38.24926 | 38.36641 | 38.48357 | 38.60072 |
| 38.71786 | 38.83501 | 38.95216 | 39.06931 | 39.18646 | 39.30361 |
| 39.42076 | 39.53791 | 39.65506 | 39.77221 | 39.88935 | 40.00651 |
| 40.12365 | 40.2408  | 40.35796 | 40.4751  | 40.59225 | 40.7094  |
| 40.82655 | 40.9437  | 41.06085 | 41.178   | 41.29514 | 41.4123  |
| 41.52945 | 41.6466  | 41.76374 | 41.88089 | 41.99804 | 42.1152  |
| 42.23234 | 42.34949 | 42.46664 | 42.58379 | 42.70094 | 42.81809 |
| 42.93524 | 43.05238 | 43.16954 | 43.28669 | 43.40384 | 43.52098 |
| 43.63813 | 43.75528 | 43.87244 | 43.98958 | 44.10673 | 44.22388 |
| 44.34103 | 44.45818 | 44.57533 | 44.69248 | 44.80963 | 44.92678 |
| 45.04393 | 45.16108 | 45.27822 | 45.39537 | 45.51252 | 45.62967 |
| 45.74682 | 45.86397 | 45.98112 | 46.09827 | 46.21542 | 46.33257 |
| 46.44972 | 46.56687 | 46.68402 | 46.80117 | 46.91831 | 47.03547 |
| 47.15261 | 47.26976 | 47.38691 | 47.50406 | 47.62122 | 47.73836 |
| 47.85551 | 47.97266 | 48.08981 | 48.20696 | 48.3241  | 48.44126 |
| 48.55841 | 48.67556 | 48.79271 | 48.90985 | 49.027   | 49.14416 |
| 49.2613  | 49.37845 | 49.4956  | 49.61275 | 49.7299  | 49.84705 |
| 49.9642  | 50.08135 | 50.1985  | 50.31565 | 50.4328  | 50.54995 |
| 50.6671  | 50.78424 | 50.9014  | 51.01854 | 51.13569 | 51.25284 |
| 51.36999 | 51.48714 | 51.60429 | 51.72144 | 51.83859 | 51.95574 |
| 52.07289 | 52.19003 | 52.30719 | 52.42433 | 52.54148 | 52.65863 |
| 52.77578 | 52.89294 | 53.01008 | 53.12724 | 53.24438 | 53.36153 |
| 53.47868 | 53.59583 | 53.71298 | 53.83013 | 53.94728 | 54.06443 |
| 54.18158 | 54.29873 | 54.41588 | 54.53302 | 54.65018 | 54.76732 |
| 54.88447 | 55.00162 | 55.11877 | 55.23592 | 55.35307 | 55.47022 |
| 55.58737 | 55.70452 | 55.82167 | 55.93881 | 56.05597 | 56.17311 |
| 56.29026 | 56.40741 | 56.52456 | 56.64171 | 56.75886 | 56.87601 |
| 56.99316 | 57.11031 | 57.22746 | 57.34461 | 57.46176 | 57.57891 |
| 57.69605 | 57.81321 | 57.93036 | 58.04751 | 58.16465 | 58.2818  |
| 58.39895 | 58.5161  | 58.63325 | 58.7504  | 58.86755 | 58.9847  |
| 59.10184 | 59.219   | 59.33615 | 59.4533  | 59.57044 | 59.6876  |
| 59.80474 | 59.9219  | 60.03904 | 60.15619 | 60.27335 | 60.39049 |

Table 21: Gaussian T1534 acceptable latitude values (continued)

|          |          |          |          |          |          |
|----------|----------|----------|----------|----------|----------|
| 60.50764 | 60.62479 | 60.74194 | 60.85909 | 60.97623 | 61.09339 |
| 61.21053 | 61.32769 | 61.44483 | 61.56199 | 61.67913 | 61.79628 |
| 61.91343 | 62.03058 | 62.14773 | 62.26488 | 62.38203 | 62.49918 |
| 62.61633 | 62.73347 | 62.85063 | 62.96778 | 63.08492 | 63.20208 |
| 63.31922 | 63.43637 | 63.55352 | 63.67067 | 63.78783 | 63.90497 |
| 64.02212 | 64.13927 | 64.25642 | 64.37356 | 64.49072 | 64.60786 |
| 64.72501 | 64.84216 | 64.95931 | 65.07647 | 65.19361 | 65.31077 |
| 65.42791 | 65.54506 | 65.66222 | 65.77936 | 65.89651 | 66.01366 |
| 66.13081 | 66.24796 | 66.3651  | 66.48226 | 66.59941 | 66.71655 |
| 66.83371 | 66.95085 | 67.06799 | 67.18515 | 67.3023  | 67.41945 |
| 67.5366  | 67.65375 | 67.7709  | 67.88805 | 68.0052  | 68.12234 |
| 68.23949 | 68.35664 | 68.4738  | 68.59094 | 68.70809 | 68.82524 |
| 68.9424  | 69.05954 | 69.17669 | 69.29384 | 69.41099 | 69.52814 |
| 69.64529 | 69.76244 | 69.87959 | 69.99673 | 70.11389 | 70.23103 |
| 70.34818 | 70.46534 | 70.58248 | 70.69963 | 70.81679 | 70.93392 |
| 71.05108 | 71.16824 | 71.28537 | 71.40253 | 71.51968 | 71.63682 |
| 71.75397 | 71.87112 | 71.98827 | 72.10542 | 72.22257 | 72.33972 |
| 72.45686 | 72.57402 | 72.69117 | 72.80832 | 72.92546 | 73.04262 |
| 73.15977 | 73.27691 | 73.39407 | 73.51122 | 73.62836 | 73.74551 |
| 73.86266 | 73.97981 | 74.09696 | 74.21411 | 74.33126 | 74.44841 |
| 74.56556 | 74.6827  | 74.79985 | 74.91701 | 75.03416 | 75.15131 |
| 75.26846 | 75.3856  | 75.50275 | 75.6199  | 75.73705 | 75.8542  |
| 75.97136 | 76.0885  | 76.20565 | 76.32279 | 76.43994 | 76.5571  |
| 76.67425 | 76.79139 | 76.90854 | 77.0257  | 77.14284 | 77.25999 |
| 77.37714 | 77.49429 | 77.61144 | 77.72859 | 77.84574 | 77.96289 |
| 78.08003 | 78.19718 | 78.31432 | 78.43148 | 78.54864 | 78.66579 |
| 78.78293 | 78.90009 | 79.01723 | 79.13438 | 79.25153 | 79.36868 |
| 79.48582 | 79.60297 | 79.72014 | 79.83728 | 79.95442 | 80.07158 |
| 80.18873 | 80.30588 | 80.42301 | 80.54017 | 80.65731 | 80.77446 |
| 80.89161 | 81.00877 | 81.12591 | 81.24307 | 81.36021 | 81.47736 |
| 81.59451 | 81.71165 | 81.82881 | 81.94596 | 82.06311 | 82.18025 |
| 82.29739 | 82.41454 | 82.53171 | 82.64886 | 82.766   | 82.88316 |
| 83.0003  | 83.11744 | 83.23459 | 83.35176 | 83.46889 | 83.58604 |
| 83.70319 | 83.82035 | 83.93748 | 84.05462 | 84.17179 | 84.28893 |
| 84.40609 | 84.52324 | 84.64039 | 84.75753 | 84.87466 | 84.99183 |
| 85.10899 | 85.2261  | 85.34326 | 85.46041 | 85.57755 | 85.6947  |
| 85.81188 | 85.92902 | 86.04616 | 86.16329 | 86.28048 | 86.39761 |
| 86.51473 | 86.63193 | 86.74905 | 86.86618 | 86.98331 | 87.10051 |
| 87.21764 | 87.33479 | 87.45193 | 87.56908 | 87.68624 | 87.8034  |
| 87.92048 | 88.03766 | 88.15485 | 88.27195 | 88.38905 | 88.50629 |
| 88.62342 | 88.74057 | 88.85756 | 88.97473 | 89.09194 | 89.20895 |
| 89.32623 | 89.44327 | 89.56031 | 89.67735 | 89.79441 | 89.90934 |

## E Polar Stereographic Domain Example

This section describes how to compute the values for the run domain and param domain sections on a polar stereographic projection.

STUB!

## F HRAP Domain Example

This section describes how to compute the values for the run domain and param domain sections on a HRAP projection.

**STUB!**

The spatial HRAP resolution has a default value of 1.0, which indicates a horizontal resolution of 4.7625 KM (valid at 1.0). Finer resolution values are then entered as 0.5, 0.25, etc. to represent half, quarter, etc. of the original 4.7625 KM gridcell length. All other HRAP-based polar stereographic grid parameters are already handled within the LDT or LIS code, since HRAP utilizes specific true latitude, standard longitude, and orientation values.

Note that HRAP is a special case of a polar stereographic grid. For HRAP,

true lat = 60.0

standard lon = -105.000

orientation = 0.0

resolution at true lat is 4.7625 km when resolution is set to 1.0; i.e.,

Run domain hrap resolution: 1

## G Mercator Domain Example

This section describes how to compute the values for the run domain and param domain sections on a Mercator projection.

Note that this projection is often used for a coupled run with the Weather Research and Forecasting (WRF) model. As such, Mercator domains are first generated when configuring WRF via WRF's preprocessing system (WPS). The domain information is then copied into LIS' *lis.config* file.

Please see WRF's User's Guide found at <http://www.mmm.ucar.edu/wrf/users/pub-doc.html> for more information.

## References

- [1] W. Sawyer and A. da Silva. Protex: A sample fortran 90 source code documentation system. Technical report, NASA GMAO, 1997. DAO Office Note 97-11.